FRESENIUS 2008H TECHNICAL MANUAL

FRESENIUS USA, INC.
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Flow Diagrams

Calibration Procedures

Troubleshooting Guide

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Preventive Maintenance Procedures

P/N 490004 REV. F

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S E C T I O N I

SPECIFICATIONS

SPECIFICATIONS

2008H HEMODIALYSIS MACHINE

Dimensions	
Total space approx.	54 x 63 cm
Height without IV pole	132 cm
Total weight approx.	73kg
Power Supply	
Line	Single phase AC 120 V±10%, 60Hz must be connected to a circuit which is equipped with a hospital grade receptacle and is protected by a circuit breaker and ground fault interrupter. Resistance from chassis to ground must be ≤ 0.2 Ohm.
Safety Group	VDE 0750 (IEC 601-1). To be operated in medical rooms which comply with VDE 0107.
Power Consumption	Does not exceed 12.0 amps
Fuses	2 each 1 Amp med. speed (5X20 mm) 1 each 16 Amp fast speed (5X20 mm) 1 each 10 Amp fast speed 2 each 2.5 Amp slow speed 1 each 16 Amp double pole rocker switch circuit breaker
Water Supply	
Water Pressure	Min. 20 psi, Max. 105 psi
Water Temperature	Min. 10°C, Max. 25°C
Quality	AAMI Standard, 1982
Quantity	1 liter/min
Drain	Approx. 3 feet maximum height. Must comply with local codes and must maintain a free fall air gap between drain hose and building drain.
Dialysate Heating	35°C to 39°C,
Heater	1300 W, electronically controlled.
Dialysate Flow	
Selectable Rates	300/500/800 ml/min. OFF for UF only

Blood Pump	
Flow Rate	0 to 600 ml/min. (with 8.0 mm pump segment)
Pump segment diameter	5 to 10 mm (.2" to .4")
Pinup segment length	32 cm minimum (12 - 5/8" min.)
Pump Revolution Range	approx. 0 - 60 rpm max.
Single Needle System	With two blood pumps, pressure - pressure control. Alarm after 15 or 30 seconds without an alternation of the pumps.
Heparin pump	
Syringe type (Fresenius)	30 ml disposable syringe
Administration Rate	0.5 to 10 ml/hr.
Monitoring	Internal monitoring with alarm.
Monitoring Elements	
Blood Circuit	
Art. press. Monitor	-280 to +300 mmHg with upper and lower alarms automatically set. (optional -80 to +500 mmHg)
Ven. press. Monitor	-80 to +500 mmHg with upper and lower alarms automatically set.
TMP Monitor	+60 to -520 mmHg with upper and lower alarms automatically set.
Air/Foam Detector	Ultrasonic impulse sensor with low frequency impulse sequence. Keying ratio 1:500.
Optical Detector	Optical transmission used to detect opaque or non - opaque presence in the extracorporeal circuit.
Blood Leak Detector	Infrared light transmitter with a control resolution of: MINOR 0.35ml blood per liter of dialysate (HCT. 25). MAJOR 0.45ml blood per liter of dialysate (HCT. 25).
Ultrafiltration Control	
Adjustment range	0 to 4000ml/hr selectable. Max. limit 1000, 2000, 3000, 4000 ml/hr set internally
UF Volume Display	Accumulator display; Max. 9.999 liters in increments of 10 ml.

PRODUCT IMPROVEMENT POLICY

The Fresenius 2008H Dialysis System was designed and built to comply with these specifications. It is the intention of Fresenius USA to continuously do product development which may result in modifications and improvements to specifications or equipment produced in the future. Such product improvements shall not incur any obligation to make similar changes or improvements to equipment previously produced. These changes or improvements may or may not be applicable or usable with previously produced equipment. Where possible, improvements will be made available at reasonable prices. Any such improvements shall not be construed as corrections of any deficiency.

S E C T I O N I I

GENERAL WARNINGS AND PRECAUTIONS

GENERAL WARNINGS AND CAUTIONS

Precautions:

Federal (USA) law restricts this device to sale only by or on the order of a physician. Frequency, duration, and parameters are to be determined by the prescribing physician.

Warnings:

The electrical source must be single phase, three conductor type provided with a hospital grade receptacle and a ground fault interrupter at 120 volts, 60 Hz. The proper polarity and ground integrity must be initially checked and thereafter maintained. Failure to do so may result in electrical shock to the operator or patient.

Shock hazard. Do not remove covers. Refer servicing to qualified personnel.

Replace fuses only with the same type and rating.

Hemolysis of blood in the dialyzer will occur should the dialysate fluid exceed a temperature of 42°C (107°F). Dialysate temperatures must be maintained below this level. Do not return hemolyzed blood to the patient.

Check the conductivity and pH of the dialysate solution with an independent device before initiating dialysis.

Indications:

Hemodialysis is indicated for patients with acute or chronic renal failure, when conservative therapy is judged to be inadequate.

Contraindications:

There are no absolute contraindications to hemodialysis, but the passing of a patient's blood through an extracorporeal circuit may require anticoagulation to prevent blood clotting. In addition, the parameters of dialysis should be optimized to avoid discomfort to the patient. Many patients are taking medicinal therapy prescribed by their physicians. Due to the dialysis treatment, some of the medication may be removed from the patient's blood thereby lowering the therapeutic level in the blood. Therefore, the prescribing physician should determine the appropriate dosage of medicine to avoid loss of the desired medicinal response in the patient.

Side Effects:

Dialysis therapy occasionally causes hypovolemia, hypervolemia, hypertension, hypotension, headache, nausea, or cramping in some patients. These symptoms are thought to occur if the patient's blood volume or electrolyte balance is not maintained within acceptable limits. Proper control of all elements of dialysis may prevent or control these physiological reactions.

Pyrogenic reactions may occur which can result in patient injury. Generally it is thought that this may be controlled by maintaining the dialysate solution within the chemical and bacteriologic limits specified in the AAMI (1982) standards for water for dialysis. A regular program for disinfection and testing of the water treatment system, piping, inlet lines, filters, and the central delivery system be established and followed. This program will vary from facility to facility.

All blood connections must be made using aseptic technique.

All tubes and connections must be checked for security and kinking to prevent loss of blood or entry of air into the extracorporeal circuit or errors in the ultrafiltration control system.

The patient's blood pressure and general physical status must be closely monitored during dialysis in order to initiate appropriate remedial measures or therapy. Of particular importance is the control of the patient's serum potassium level as well as the patient's blood clotting time.

Warning: Failure to install, operate, and maintain this equipment according to manufacturers' instructions may cause patient injury.

Warning: Calibrations and maintenance procedures must not be carried out while a patient is connected to the bedside station. If possible, it is a good practice to remove the machine from the treatment area when the machine is being serviced. The machine should be labeled with it's status so that is not accidentally used while still undergoing service operations.

Caution: Calibration procedures should be against either primary standards or against standards that are regularly calibrated in a program where the basic standards are traceable to the National Institute of Standards and Technology (National Bureau of Standards).

Warning: Any machine filled with a chemical for cleaning or disinfection must be clearly labeled by the operator. The label should indicate what the chemical is and that rinsing and testing is required before clinical use of the dialysate delivery machine.

Warning: At the end of the rinsing process, after chemical disinfection, the drain water must be tested for disinfectant residual.

Warning: The 2008H Hemodialysis machine is compatible with a number of venous lines. The air/foam detection circuit must be calibrated for the model line you are using. During calibration the filter inside the drip chamber must be below the sensor heads. Refer to the calibration instructions. In addition, verify that the venous clamp is capable of fully occluding the line.

Warning: During the priming procedure verify that an air alarm causes the blood pump to stop and the venous clamp to close and the line to be clamped.

Caution: An uncontaminated transducer protector should be placed on all the air connections from the drip chambers to the machine pressure connections. This will prevent contamination of the machine and filter air which enters the chambers through the monitor lines.

Caution: It is absolutely necessary that the dialyzer couplings close tightly so that, with negative pressure on the dialysate compartment, air cannot leak into the dialysate circuit or if under positive pressure, fluid cannot leak out, adding to the intended ultrafiltration. This condition is of special importance with non - standardized dialyzer connections.

S E C T I O N I I I

HYDRAULIC DESCRIPTION

DESCRIPTION OF THE HYDRAULIC COMPONENTS

All valves and motors are supplied with 24V DC; the heater is supplied with 120V AC 60Hz; thermistors, float switch, blood leak detector, pressure sensors and reed switches with 12V DC; conductivity cell and level sensor with 12V AC at high frequencies;

Inlet filter screen
prevents the 2008H components from being obstructed (mounted in the inlet water line of the 2008H).

Water inlet regulator
limiting the inlet water pressure.

Balancing chamber
The most important component for volumetric dialysate balancing; two spherical chambers (30m1 each); 8 solenoid valves; two membranes reliable and proven hydraulic component from A2008C/D/E series; guarantees accurate fluid balancing.

Hydroblock
consists of heater; including valve “39” and an orifice to provide sufficient volume to deaerate the water; separates the air from the dialysate and provides mounting for the loading pressure valve; control NTC 2 (temperature sensor for temperature control circuit).

function: warming and mixing dialyzing fluid; provides air gap and a level sensor to maintain the water level.

Monitoring NTC 3
function: independent temperature sensor for temperature monitoring.

Flow indicator
optical flow indication and gross flow measurement.

Dialyzer valves V24, V25, and bypass valve V26
bypasses (V24 closed, V25 and V26 open) the dialyzer and prevents exposure of the patient to improper dialyzing fluid (temperature> 41° C); the dialyzer can be isolated (V24 and V25 closed, V26 open; i.e. for pressure holding test or TMP alarm.

Dialysate line safety interlock
2 switches for dialysate lines;
1 switch for interlock cover;
provides additional safety against inadvertently rinsing or disinfection;
defines dialyzer emptying program.

Dialyzer filter
prevents hydraulic components from being obstructed; mounted outside 2008H; easy to service.

Pressure transducer
pressure transducer for dialysate pressure measurement; used also as a sensor for the pressure holding test.

Blood leak detector
color sensitive blood leak detector (temperature compensated), is able to distinguish between opaque layers in the cell and real presence of blood in the dialyzing fluid.

Secondary air separator
guarantees precise weight removal; device contains fluid level detector, air separation volume and valve V43.

Flow pump pressure transducer
provides pressure peak to switch the balance chamber and to control the flow pump speed.

Flow pump
DC motor driven gear pump;
function: filling of the balancing chamber.

Deaeration pump
provides deaeration and loading pressure.

Heat exchanger
preheats inlet water.

Conductivity cell
measures conductivity.

UF pump
responsible for fluid removal

Concentrate pump
delivers acetate or acid concentrate to the water inlet chamber; proportioned by the microprocessor according to settings in the DIALYSATE COMPOSITION SCREEN.

Bicarbonate pump
delivers bicarbonate to the recirculation chamber; proportioned by the microprocessor according to settings in the DIALYSATE COMPOSITION SCREEN.

Recirculation valve V29
allows fluid to the drain to be diverted into the hydroblock; used in heat disinfect to heat up faster and to conserve energy.

1. Time constants

The overlap time (dead time) of the balancing chamber valves is always 50 ms. This time is included in the switching time of the balance chamber (ie. switching time is 6.00 seconds means 5.95 sec. fill time plus 50 ms dead time).

UF pump pulse width = 250 ms

Time constants of the balance chamber.

Flow rate 300 ml/min t = 6.0 s ± 10%
Flow rate 500 ml/min t = 3.6 s ± 10%
Flow rate 800 ml/min t = 2.25 s ± 10%
Rinse flow rate 750 ml/min t = 2.9 s ± 10%

2. Rinse

Rinse can always be started if the concentrate and bicarbonate connectors are in their rinse ports, the dialyzer couplings are connected to the shunt and the shunt door is closed.

At the beginning of rinse the hydraulics are flushed with the heater off. Valves V30, V31, V32, V33, V34, V35, V36, V37, V38, V24, V25, V39, the deaeration pump and the flow pump on and the concentrate pumps run max. stroke volume and max. frequency for 50 seconds; about half way in this cycle (30 sec.) V30 should be closed for 2 seconds (rinse of the loading pressure valve), V26 opens and V24/V25 close.

During the remainder of the rinse cycle, the hydraulics follow a pattern where the dialyzer and bypass valves alternate, the recirculation valve and the drain valve alternate, the balancing chamber switches (valve combinations as specified), the UF—pump runs at 3000 ml/h, V43 alternates on/off, and the concentrate and bicarbonate pump stroke every balancing chamber cycle. This pattern assures that all the various parts of the hydraulics gets adequately rinsed.

The rinse program lasts until it is stopped by the timer being 0 or by the operator (the machine displays the message “INTERRUPTED” in the status line). The set time and the remaining time on rinse are displayed on the screen.

3. Mandatory Rinse

Mandatory rinse has to be performed always after a CHEMICAL disinfection and/or ACID CLEAN. The user is informed about this need by a message in the status line on the screen. The only difference between mandatory rinse and a regular rinse program is, that the mandatory rinse has to run for a predefined time and cannot be terminated.

Mandatory rinse can always be started if the concentrate and bicarbonate connectors are in their rinse ports, the dialyzer couplings are connected to the shunt and the shunt door is closed.

During mandatory rinse the set time and the remaining time are displayed. If the remaining time is zero the machine stops and displays a message "FINISHED".

NOTE: If the machine was turned of f or wands are pulled during mandatory rinse before the needed time was over the machine comes up with mandatory rinse again after power on.

4. Chemical Disinfection

There are two different chemical disinfection procedures.

A. Disinfect/Rinse (followed immediately by a mandatory rinse)

B. Disinfect/Dwell (mandatory rinse may be done at a later time or date)

Chemical disinfection can always be started if the concentrate and bicarbonate connectors are in their rinse ports, the dialyzer couplings are connected to the shunt and the shunt door is closed.

After either chemical disinfection cycle is selected, the concentrate pumps run max. stroke volume and max. frequency for five strokes (If the wands are disconnected during this "pump rinse", the machine will go back to the opening screen with an appropriate message on the status line). Now a message appears "CONNECT DISINFECTANT" for getting the disinfectant connected by the operator. The operator must press reset to confirm connection. If the machine was not rinsed before (check the above mentioned flag) a preparing rinse (without running the concentrate pump) has to be performed (ACID CLEAN does not have this preparing rinse). The user is informed about this by a message on the display. The time left for this preparation is displayed. After a sufficient rinse, the machine will dispose of 30m1 fluid and not replace it by opening the inlet valve. Start to pull up the chosen disinfectant with the flow off and the acid pump run at max. frequency until the float switch responds or for max. of 50 strokes (alarm message in status line "NO DISINFECTANT". Now the disinfection process will begin and the timer will start (Valve switching as in rinse). At the end of chemical disinfect the machine requests that the wands are connected to the ports. As soon as the wands are in their ports the machine will in case **A)** automatically run a rinse cycle and in case **B)** the concentrate pump runs for 15 ml (max. volume max. speed) with the deaeration pump on (to prevent the exposure of springs and seals to pure disinfectant for a long time).

NOTE: If there is any action required and the user doesn't respond to the request within a certain time, the machine creates an audible warning.

5. Heat disinfect

Heat disinfect can always be started if the concentrate and bicarbonate connectors are in their rinse ports, the dialyzer couplings are connected to the shunt and the shunt door is closed.

If the machine has performed any program other than rinse or heat disinfect before, the heat disinfect program always starts with a regular rinse for 7 minutes to rinse out concentrate or any disinfectant. This is not displayed on the screen.

After this, the machine starts running in recirculation mode (V29 open and V30 closed). When the water temperature reaches 80°C, the timer starts decrementing until it reaches 0 and the cycle is finishes. The set time and the time left are displayed on the screen. If the predefined time has elapsed, the machine turns off all pumps and valves and displays the message "FINISHED" in the status line.

NOTE: This time is selectable by the user in the service program.

NOTE: There is no automatic "cool down cycle" at the end of heat disinfect. If the user tries to start dialysis while the temperature is above 41°C, dialysis is started with valve V39 open until the temperature goes below 41°C.

6. Flow off

After the flow has been turned off from the front panel, the heater is turned off and the deaeration pump will turn off after one minute.

7. No program mode (opening screen)

In "no program state" everything is off. Alarms are not active nor displayed. If blood is sensed there will be an audible alarm and a message in the display. The heater is disabled.

8. Adjusting TMP

The TMP display flashes alternately two messages "TMP : 120"(current pressure) and "TMP : LOW" or "TMP : HI". The alarm limits are displayed in the status line. There will be an audible alarm, if conditions for audible are given. Isolate the dialyzer, open valve 26 and close valves 24 and 25. The flow is turned off. If the dialysate pressure is above zero, 50 milliseconds later valve 43 opens for 0.1 sec. to vent pressure to atmosphere. If dialysate pressure is 0 or negative, valves V31, V32, V33, V34 open for 0.1 sec. to vent pressure.

9. Fill mode

Flow rate is 300 (about 4 volts to the flow pump pressure lower than loading pressure, because V43 is open and the fresh filled chamber may be partially emptied by dialysate being pressed back by the flow pinup). The balance chamber will be switched by the CFS sensor (threshold lower than loading pressure). As long as the deaeration pump is filling the BC, the dialysate (CFS) pressure should be fairly low. If both chambers are filled, the pressure will peak (just like in regular dialysis). This big pressure peak is used to switch the BC. This insures that the correct proportioning of the concentrates is given. The level sensor #6 is only checked at the end of the cycle. If there is still air in the air separator, the next cycle is performed. If not, the machine will go on with dialysis. If the fill mode occurs with the venous pressure >50 mmHg and/or blood is sensed (patient is connected to the machine) valves 24 and 25 are off and valve 26 is on during fill mode. UF is stopped during fill. If fill is running for more than 10 chamber cycles (300 ml) there will be a permanent fill alarm and a displayed message, if the dialyzer connectors are out of the shunt door.

Remark: Fill mode starts and ends always after a complete cycle.

Dialysis cycle one is followed by fill cycle two.
Dialysis cycle two is followed by fill cycle one.
Fill cycle one is followed by dialysis cycle two.
Fill cycle two is followed by dialysis cycle one.

10. Flow alarm (See further information in Section VII, ACTUATOR BOARD)

Flow alarm will occur if:

a. The float switch opens valve 41, and the water level isn't up within the next 5 sec. All balance chamber valves shut off, heater is off until the sensor detects water (water shortage alarm).

b. If the float switch does not detect a low level within 2.5 sec. after the balance chamber did cycle. Exception is recirculation.

Heater off - "Eigentakt".

c. The CFS (chamber full switch) does not switch the balance chamber for 10 sec. Exception is flow off and non program state. Heater off - "Eigentakt".

d. The CFS switches the chamber faster than 1.8 sec. Heater off.

DISTRIBUTION BOARD LAYOUT

11. Definition of component function

2. Temperature control thermistor
   Controls temperature in the heater chamber.

3. Temperature monitor thermistor
   Monitors temperature in the conductivity cell block, bypass is initiated when temperature is out of limits.

4. Not Used

5. Level sensor in water inlet chamber
   Controls water inlet valve 41 and it's signal is used to detect flow problems.

6. Air sensor in air separator chamber
   Detects air coming from the dialyzer and is used to trigger the fill mode.

7. conductivity cell
   Monitors the conductivity, bypass is initiated when conductivity is out of limits.

8. Blood leak detector
   Finds blood in the return line of the dialyzer and triggers the minor blood leak warning and the blood leak alarm.

9. Dialysate pressure transducer
   Measures the dialysate pressure. This value is used to calculate the TMP.

10. Chamber full switch
    The pressure spike seen by this transducer is used to switch the balance chamber. The time between pulses and the selected flow rate will set the voltage to the flow pump. It is intended to limit the height of the pressure spike to a certain value (a little higher than the loading pressure at all pump speeds).

11. Reed switch for concentrate connector - disables the concentrate pump.

12. Reed switch for bicarbonate connector - disables the bicarbonate pump.

13. Not Used

14. Not Used

15. Not Used

16. Concentrate pump with end of stroke sensor

    Delivers acetate or acid concentrate into the water inlet chamber. It will fully discharge it's volume and refill on every switching of the balance chamber.
    The volume calibration is done by means of using a graduated cylinder and adjusting the number of steps (in software) for a specific volume.

17. Bicarbonate pump with end of stroke sensor

    If enabled (see # 11), this pump delivers bicarbonate into the recirculation chamber. It will fully discharge its volume and refill (possibly twice depending on the volume needed for the concentrate selected) on every switching of the balance chamber. The volume calibration is done by means of using a graduated cylinder and adjusting the number of steps (in software) for a specific volume.

18. Not Used

19. Not Used

20. Deaeration pump

    Is calibrated in software, using a pressure gauge on the inlet of the pump.
    The pressure is set to -24 inches of Hg (-0,8 bar).

21. Flow pump

    It is controlled by software. The pump speed depends on the flow rate selected and the time between balance chamber switching(CFS).

22. UF pump

    The volume is calibrated to 1ml per stroke. The frequency of strokes is controlled by software.

23. Not Used

24. Dialysate valve 1

25. Dialysate valve 2

26. Bypass valve

28. Not Used

29. Recirculation valve

30. Drain valve

31 Balance chamber valve

32. Balance chamber valve

33. Balance chamber valve

34. Balance chamber valve

35. Balance chamber valve

36. Balance chamber valve

37. Balance chamber valve

38. Balance chamber valve

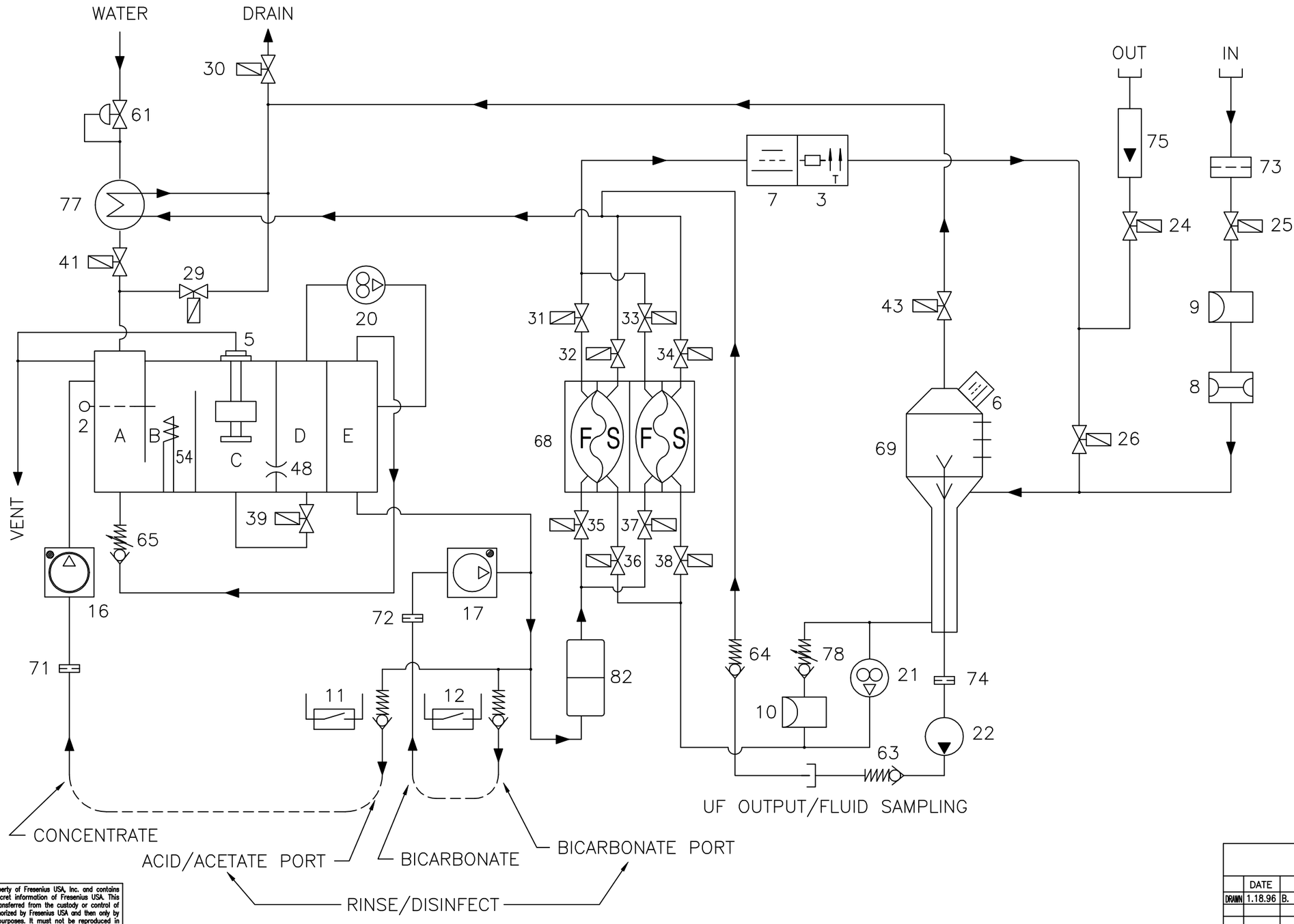
39. Bypass valve for deaeration orifice.
    This valve is on in all cleaning cycles.

41. Water Inlet Valve
    This valve is controlled via level sensor #5.

43. Vent valve for air separator

HYDRAULICS: FRESENIUS 2008H

REV	ECO #	BY	DATE	CHK	REVISION
A	5401	BH	1.18.96	MJC	RELEASE
B	6470	BH	7.7.98	RH	ADD PAGES 2, 3, AND 4



COMPONENT LIST FOR FLOW DIAGRAM 2008H

2. TEMPERATURE CONTROL THERMISTOR
3. TEMPERATURE MONITOR THERMISTOR
5. FLOAT SWITCH
6. AIR SENSOR IN AIR SEPARATOR CHAMBER.
7. CONDUCTIVITY CELL
8. BLOOD LEAK DETECTOR
9. DIALYSATE PRESSURE CHAMBER
10. CHAMBER FULL SWITCH
11. REED SWITCH CONCENTRATE WAND
12. REED SWITCH BICARBONATE WAND
16. CONCENTRATE PUMP
17. BICARBONATE PUMP
20. DEAERATION PUMP
21. FLOW PUMP
22. UF PUMP
24. DIALYZER VALVE 1
25. DIALYZER VALVE 2
26. BYPASS VALVE
29. RECIRCULATION VALVE
30. DRAIN VALVE
31. BALANCE CHAMBER VALVE
32. BALANCE CHAMBER VALVE
33. BALANCE CHAMBER VALVE
34. BALANCE CHAMBER VALVE
35. BALANCE CHAMBER VALVE
36. BALANCE CHAMBER VALVE
37. BALANCE CHAMBER VALVE
38. BALANCE CHAMBER VALVE
39. BYPASS VALVE FOR DEAERATION ORIFICE
41. WATER INLET VALVE
43. VENT VALVE FOR AIR SEPARATION CHAMBER
48. DEAERATION ORIFICE
54. HEATER
61. WATER INLET PRESSURE REGULATOR
63. CHECK VALVE FROM UF PUMP TO SAMPLE PORT
64. CHECK VALVE FROM SAMPLE PORT TO DRAIN
65. LOADING PRESSURE VALVE
69. AIR SEPARATION CHAMBER
71. ACID/ACETATE CONNECTOR WITH FILTER
72. BICARBONATE CONNECTOR WITH FILTER
73. FROM DIALYZER LINE FILTER
74. UF PUMP FILTER
75. DIALYSATE LINE FLOW INDICATOR
77. HEAT EXCHANGER
78. FLOW PUMP PRESSURE RELIEF VALVE
82. MIXING CHAMBER FOR BICARBONATE

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	DATE	NAME
DRAWN	1.18.96	B. HOLMQUIST

MATERIAL

2008H HYDRAULIC FLOW DIAGRAM

SCALE NONE

FRESENIUS

700070

REV. B

SHEET 1 OF 4

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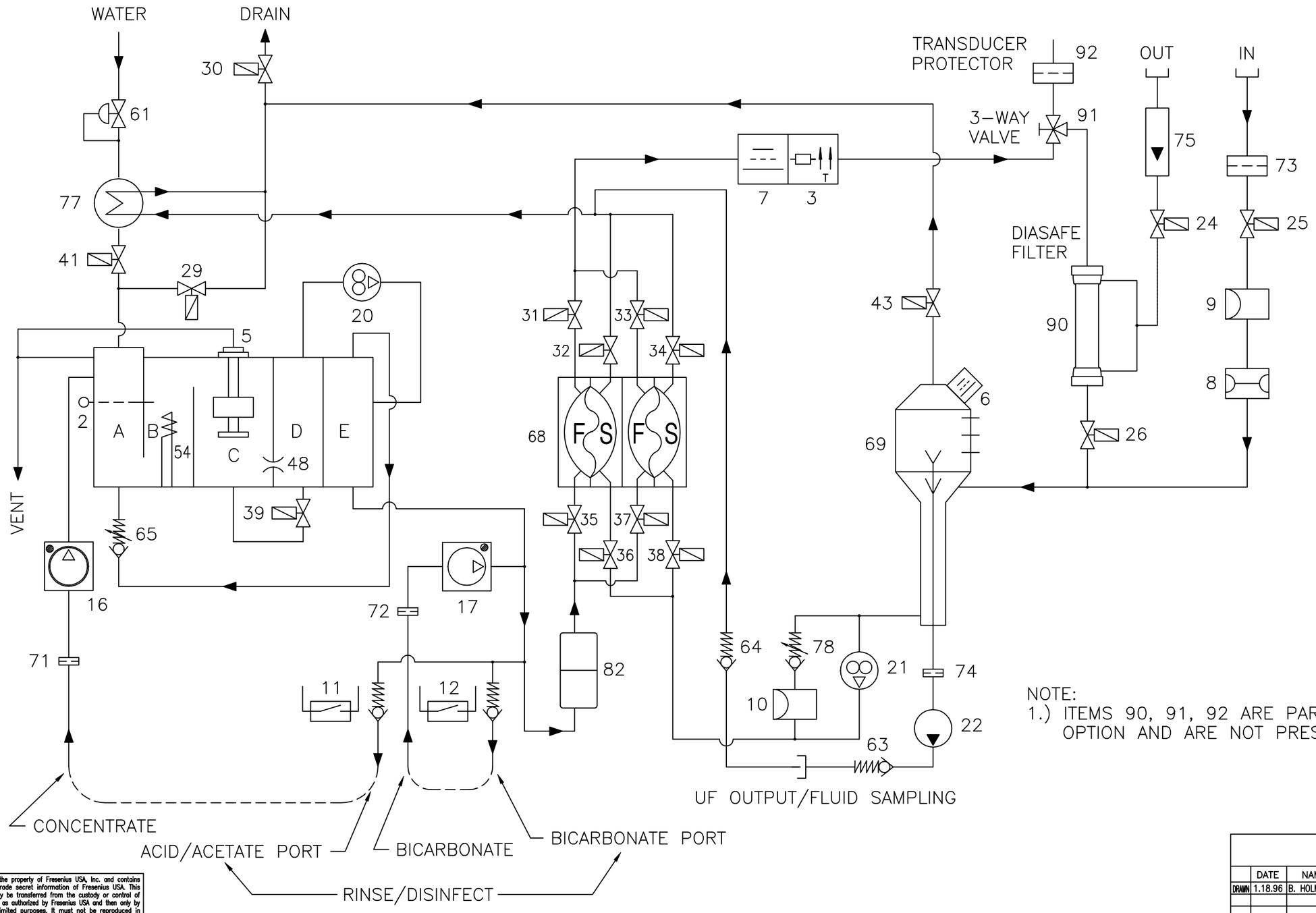
HYDRAULICS: FRESENIUS 2008H WITH DIASAFE FILTER

REV	ECO #	BY	DATE	CHK	REVISION
A	5401	BH	1.18.96	MJC	RELEASE
B	6470	BH	7.7.98	RH	ADD ITEMS 90, 91, 92



COMPONENT LIST FOR FLOW DIAGRAM 2008H

2. TEMPERATURE CONTROL THERMISTOR
3. TEMPERATURE MONITOR THERMISTOR
5. FLOAT SWITCH
6. AIR SENSOR IN AIR SEPARATOR CHAMBER.
7. CONDUCTIVITY CELL
8. BLOOD LEAK DETECTOR
9. DIALYSATE PRESSURE CHAMBER
10. CHAMBER FULL SWITCH
11. REED SWITCH CONCENTRATE WAND
12. REED SWITCH BICARBONATE WAND
16. CONCENTRATE PUMP
17. BICARBONATE PUMP
20. DEAERATION PUMP
21. FLOW PUMP
22. UF PUMP
24. DIALYZER VALVE 1
25. DIALYZER VALVE 2
26. BYPASS VALVE
29. RECIRCULATION VALVE
30. DRAIN VALVE
31. BALANCE CHAMBER VALVE
32. BALANCE CHAMBER VALVE
33. BALANCE CHAMBER VALVE
34. BALANCE CHAMBER VALVE
35. BALANCE CHAMBER VALVE
36. BALANCE CHAMBER VALVE
37. BALANCE CHAMBER VALVE
38. BALANCE CHAMBER VALVE
39. BYPASS VALVE FOR DEAERATION ORIFICE
41. WATER INLET VALVE
43. VENT VALVE FOR AIR SEPARATION CHAMBER
48. DEAERATION ORIFICE
54. HEATER
61. WATER INLET PRESSURE REGULATOR
63. CHECK VALVE FROM UF PUMP TO SAMPLE PORT
64. CHECK VALVE FROM SAMPLE PORT TO DRAIN
65. LOADING PRESSURE VALVE
69. AIR SEPARATION CHAMBER
71. ACID/ACETATE CONNECTOR WITH FILTER
72. BICARBONATE CONNECTOR WITH FILTER
73. FROM DIALYZER LINE FILTER
74. UF PUMP FILTER
75. DIALYSATE LINE FLOW INDICATOR
77. HEAT EXCHANGER
78. FLOW PUMP PRESSURE RELIEF VALVE
82. MIXING CHAMBER FOR BICARBONATE
90. DIASAFE FILTER
91. 3–WAY VALVE
92. TRANSDUCER PROTECTOR

NOTE:
1.) ITEMS 90, 91, 92 ARE PART OF THE DIASAFE FILTER OPTION AND ARE NOT PRESENT ON ALL MACHINES.

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	DATE	NAME
DRAWN	1.18.96	B. HOLMQUIST

MATERIAL

2008H HYDRAULIC FLOW DIAGRAM

SCALE NONE

FRESENIUS

700070

REV. B

SHEET 2 OF 4

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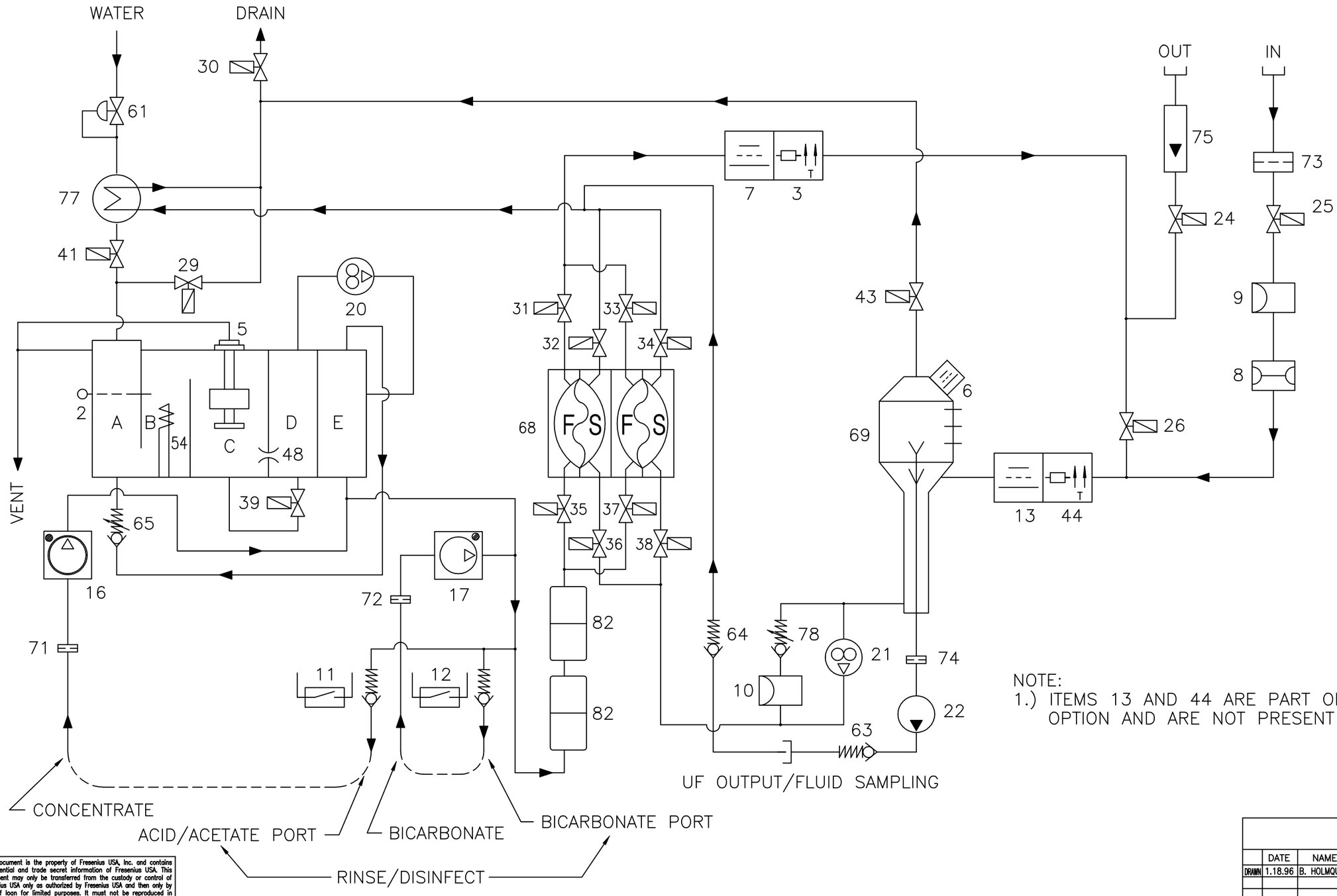
HYDRAULICS: FRESENIUS 2008H WITH ONLINE CLEARANCE

REV	ECO #	BY	DATE	CHK	REVISION
A	5401	BH	1.18.96	MJC	RELEASE
B	6470	BH	7.7.98		ADD ITEMS 13, 44



COMPONENT LIST FOR FLOW DIAGRAM 2008H

2. TEMPERATURE CONTROL THERMISTOR
3. TEMPERATURE MONITOR THERMISTOR
5. FLOAT SWITCH
6. AIR SENSOR IN AIR SEPARATOR CHAMBER.
7. CONDUCTIVITY CELL
8. BLOOD LEAK DETECTOR
9. DIALYSATE PRESSURE CHAMBER
10. CHAMBER FULL SWITCH
11. REED SWITCH CONCENTRATE WAND
12. REED SWITCH BICARBONATE WAND
13. 2ND CONDUCTIVITY CELL
16. CONCENTRATE PUMP
17. BICARBONATE PUMP
20. DEAERATION PUMP
21. FLOW PUMP
22. UF PUMP
24. DIALYZER VALVE 1
25. DIALYZER VALVE 2
26. BYPASS VALVE
29. RECIRCULATION VALVE
30. DRAIN VALVE
31. BALANCE CHAMBER VALVE
32. BALANCE CHAMBER VALVE
33. BALANCE CHAMBER VALVE
34. BALANCE CHAMBER VALVE
35. BALANCE CHAMBER VALVE
36. BALANCE CHAMBER VALVE
37. BALANCE CHAMBER VALVE
38. BALANCE CHAMBER VALVE
39. BYPASS VALVE FOR DEAERATION ORIFICE
41. WATER INLET VALVE
43. VENT VALVE FOR AIR SEPARATION CHAMBER
44. 2ND TEMPERATURE MONITOR THERMISTOR
48. DEAERATION ORIFICE
54. HEATER
61. WATER INLET PRESSURE REGULATOR
63. CHECK VALVE FROM UF PUMP TO SAMPLE PORT
64. CHECK VALVE FROM SAMPLE PORT TO DRAIN
65. LOADING PRESSURE VALVE
69. AIR SEPARATION CHAMBER
71. ACID/ACETATE CONNECTOR WITH FILTER
72. BICARBONATE CONNECTOR WITH FILTER
73. FROM DIALYZER LINE FILTER
74. UF PUMP FILTER
75. DIALYSATE LINE FLOW INDICATOR
77. HEAT EXCHANGER
78. FLOW PUMP PRESSURE RELIEF VALVE
82. MIXING CHAMBER FOR BICARBONATE

NOTE:
1.) ITEMS 13 AND 44 ARE PART OF THE ONLINE CLEARANCE OPTION AND ARE NOT PRESENT ON ALL MACHINES.

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	DATE	NAME
DRAWN	1.18.96	B. HOLMQUIST

MATERIAL

2008H HYDRAULIC FLOW DIAGRAM

SCALE NONE

FRESENIUS

700070

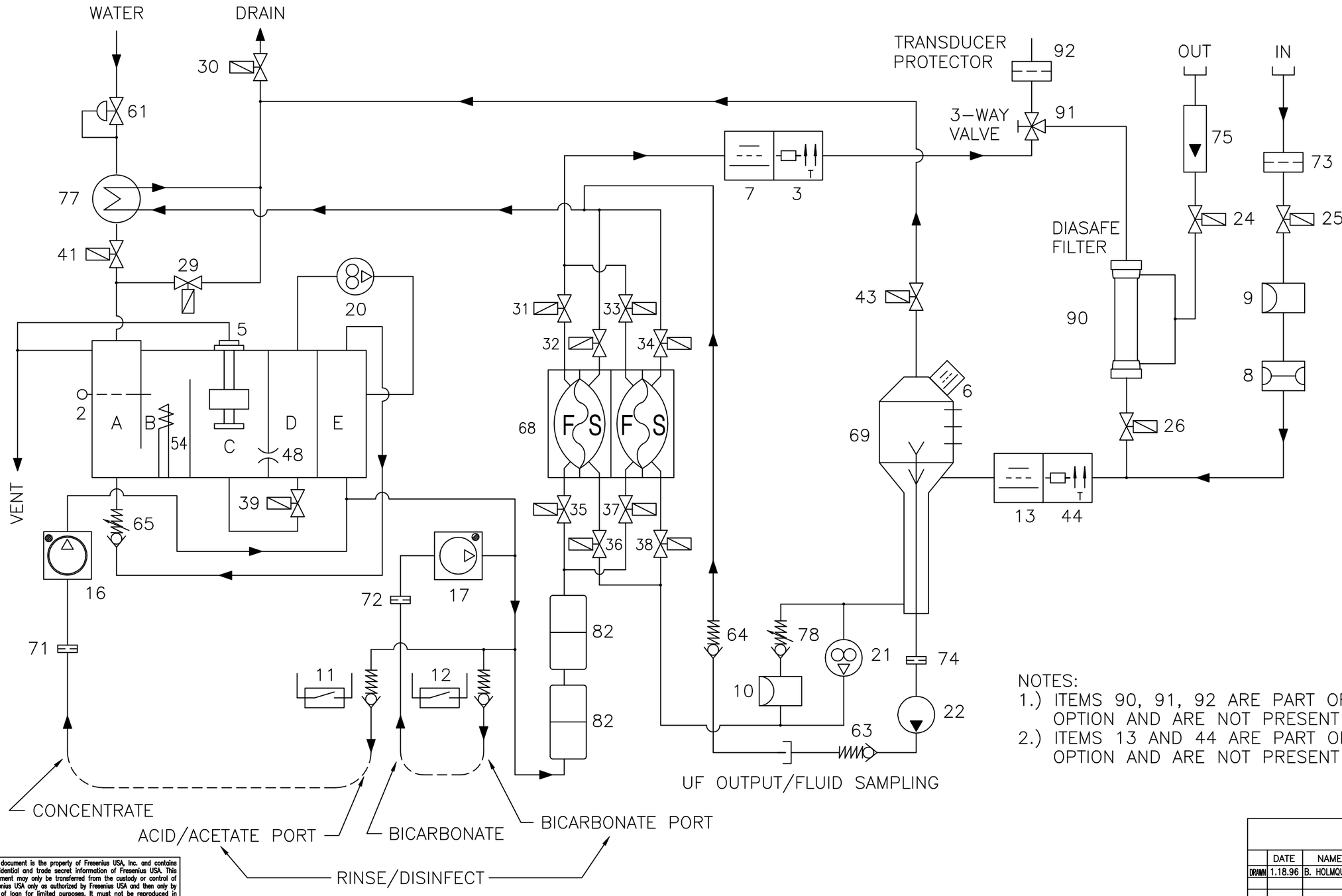
REV. B

SHEET 3 OF 4

O:\ACAD\7\700070-3.DWG

HYDRAULICS: FRESENIUS 2008H WITH DIASAFE FILTER AND ONLINE CLEARANCE

REV	ECO #	BY	DATE	CHK	REVISION
A	5401	BH	1.18.96	MJC	RELEASE
B	6470	BH	7.7.98	RH	ADD ITEMS 13, 44, 90, 91, 92



COMPONENT LIST FOR FLOW DIAGRAM 2008H

2. TEMPERATURE CONTROL THERMISTOR
3. TEMPERATURE MONITOR THERMISTOR
5. FLOAT SWITCH
6. AIR SENSOR IN AIR SEPARATOR CHAMBER.
7. CONDUCTIVITY CELL
8. BLOOD LEAK DETECTOR
9. DIALYSATE PRESSURE CHAMBER
10. CHAMBER FULL SWITCH
11. REED SWITCH CONCENTRATE WAND
12. REED SWITCH BICARBONATE WAND
13. 2ND CONDUCTIVITY CELL
16. CONCENTRATE PUMP
17. BICARBONATE PUMP
20. DEAERATION PUMP
21. FLOW PUMP
22. UF PUMP
24. DIALYZER VALVE 1
25. DIALYZER VALVE 2
26. BYPASS VALVE
29. RECIRCULATION VALVE
30. DRAIN VALVE
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74. UF PUMP FILTER
75. DIALYSATE LINE FLOW INDICATOR
77. HEAT EXCHANGER
78. FLOW PUMP PRESSURE RELIEF VALVE
82. MIXING CHAMBER FOR BICARBONATE
90. DIASAFE FILTER
91. 3–WAY VALVE
92. TRANSDUCER PROTECTOR

NOTES:
1.) ITEMS 90, 91, 92 ARE PART OF THE DIASAFE FILTER OPTION AND ARE NOT PRESENT ON ALL MACHINES.
2.) ITEMS 13 AND 44 ARE PART OF THE ONLINE CLEARANCE OPTION AND ARE NOT PRESENT ON ALL MACHINES,

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	DATE	NAME	MATERIAL	
DRAWN	1.18.96	B. HOLMQUIST	2008H HYDRAULIC FLOW DIAGRAM	SCALE NONE
			700070	REV. B
FRESENIUS			O:\ACAD\7\700070-4.DWG	SHEET 4 OF 4

S E C T I O N I V

ELECTRONIC CIRCUIT DESCRIPTION

BRIEF DESCRIPTION OF 2008H ELECTRONICS

POWER CONTROL BOARD

DISPLAY BOARD

MOTHER BOARD

POWER LOGIC BOARD

ACTUATOR BOARD

FUNCTIONAL BOARD

TEST BOARD

SENSOR BOARD

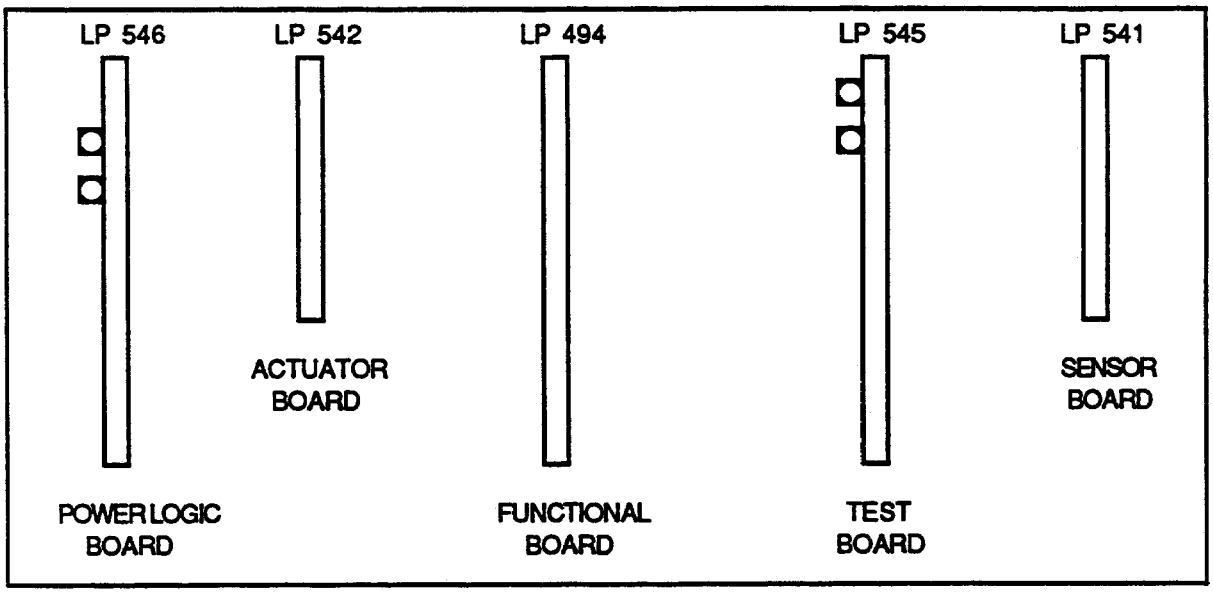
DISTRIBUTION BOARD

BLOOD LEAK DETECTOR BOARD

FUNCTION AND LOCATION OF PCB'S

BOARD	LOCATION	DESCRIPTION
Power Control	Power Supply	Magnetic regulated power supply, 24V, heater supply, stand-by power supply and heater control circuit.
Display board	Monitor	Operating & indicating elements (keys, barographs, displays, coding and decoding elements)
Mother board	Monitor	Distribution board for monitor boards
Power Logic board	Monitor	+5, +12, DC to DC converter
Actuator board	Monitor	Drivers and control for valves, pumps and monitor board interface for sensor and secondary monitor (independent A/D converter) circuits
Functional board	Monitor	Functional processor; operating logic control and control of displays
Test board	Monitor	Monitor for functional board watchdog, test signal generator
Sensor board	Monitor	Amplifiers for pressure transducer, temperature, conductivity and other sensors, ADC's
Distribution board	Hydraulic	Interconnection of hydraulic components to monitor
Blood Leak Detector	Hydraulic	Potted SMD board, BLD electronics

2008H BOARD LAYOUT



ON/OFF 24VOLTS 12VOLTS 5VOLTS	PUMPS VALVES	SOFTWARE TOUCH PADS SWITCHES	SELF TEST	BLOOD LEAK TRANSDUCERS

2008H REAR PANEL OPERATING ELEMENTS

Remark: Position numbers [ ] are referring to enclosed rear panel schematic!

EXTERNAL COMMUNICATION PANEL

LOUDSPEAKER [1]

The machine can make two kinds of sounds: a warning sound, made with the WARNING-SOUND-ON output, and an alarm sound, made with the ALARM-SOUND-ON output. The two sounds are quite distinct; the first one is used for lower priority problems, and the second for more important problems.

Also, the machine has a heater relay and watchdog relay, both of which make small clicks when they change state. However, these clicks will not be audible to the casual observer.

SERIAL INTERFACE [2] standard RS 232 serial interface connector; hard wired, used for display terminal connection, FDS-08

POWER FAILURE ALARM 9V alkaline battery for main power failure

EXTERNAL ALARM INPUT [8] input line for external alarm; activates EXTERNAL ALARM function of the 2008H

STAFF CALL [9] output line for transferring 2008H alarm condition to central control system

DIALYSIS STATUS INDICATOR for traffic light connection

HYDRAULIC CONNECTION PANEL

TO DIALYZER [10] tube to dialyzer

FROM DIALYZER [11] tube from dialyzer

WATER INLET [12] tube for water inlet

TO DRAIN [13] outlet tube to drain

GROUND [14] fixing screw for potential equalization

POWER SUPPLY PANEL

HEATER BREAKER [15] separate line voltage breaker for heater element

MAIN BREAKER [16] main line voltage switch

POWER CABLE [18] cable connection to wall socket

ELECTRONIC BOARD DESCRIPTIONS

FRONT PANEL AND DISPLAY

1. Overview

The 2008H Display Panel Assembly provides control input and visual feedback of the current operational status of the 2008H. The three major components of the 2008H Display Panel Assembly are the Front Panel, the Display Board, and the Plasma Display.

The Front Panel consists of a metal base plate with a plastic overlay. The Display Board and the Plasma Display are attached to the Front Panel using PEM studs. The metal base plate has cutouts that correspond to the locations where the LEDs on the Display Board will show through, and for where the Plasma Display is mounted. The plastic overlay is silk-screened with text, functional grouping lines, and shaded squares to show the location of the membrane switches that are embedded within the overlay. Also incorporated in the plastic overlay are colored lenses over the cutouts for the Display Board LEDs and a polarized filter over the cutout for the Plasma Display.

The Display Board provides the interface and control for the Plasma Display and the LEDs. The High Voltage Power Supply for the Plasma Display may also be on the Display Board. Several different types and colors of LED modules are used to display the status and operating mode of the 2008H. Bar Graph LED modules are used to display the Venous and Arterial Pressures. The Functional Board provides the data that drives the LEDs and the Plasma Display.

The Plasma Display is a 128 x 64 pixel graphic display module through which extensive textual and graphical information can be displayed pertaining to the current operational status, diagnostics functions, or calibrations. All of these are controlled by the 2008H Functional Board under software control.

2. LEDS

The front panel has 23 LEDs, 22 of which are controlled by the functional board. These are used primarily to indicate alarms and machine states. A flashing LED either may indicate the first blood alarm, when multiple blood alarms occur; or a key that user can press for a special response. During the light show, the LEDs are tested, one by one. At other times, they have the following meanings:

1. **Power** - Lit indicates the machine is on; this is not controlled by the functional board.
2. **Reset** - Lit normally. Flashing if the message displayed asks the user if they want new arterial, venous, or TMP limits. Off during rinse or if there are any alarms.
3. **Mute** - Lit if muting is active.
4. **Normal** - Lit if the alarm and warning LEDs are both out.
5. **Warning** - Lit if the machine is in dialysis, and is not in the test, and there is either a warning or a brief message; or, if there has been a fatal alarm, with the machine in rinse.
6. **Alarm** - Lit if there is an alarm, or a test step has failed.
7. **Air Detector** - Flashes if a Level Detector Alarm is the primary alarm. Otherwise, lit if there is a Level Detector Alarm or if the machine is in prime.
8. **Blood Leak Detector** - Flashes if a Blood Leak Alarm is the primary alarm. Otherwise, lit if there is a Blood Leak Alarm.
9. **Blood Leak Minor** - Lit if there is a Blood Leak Warning.
10. **Arterial Pressure** - There are three LEDs for this function. The middle LED is not directly controlled by the functional board; it is lit or flashes whenever the upper or lower LEDs are lit or flash. The upper and lower LEDs will flash for a primary alarm or be lit for a non—primary alarm. The upper LED refers to a High Soft/Hard Limit Alarm; the lower LED refers to a Low Soft/Hard Limit Alarm.
11. **Venous Pressure** - As per arterial pressure.
12. **Prime** - Lit during priming.
13. **Override** - Lit while Blood Leak Alarms are overridden.
14. **Test** - Flashing during the test when the user must press the Test key to go on; otherwise, lit during the test.
15. **UF On/Off** - Flashes if the user has selected UF on but UF is not actually on7 otherwise, lit if UF is actually on.
16. **Dialysate Flow On/Off** - Flashes if flow is of f (detected by the FLOW-STOP-ACKNOWLEDGE pin going high).
17. **Bypass** - Lit if the machine is in bypass.
18. **Sodium Variation** - Flashes if an SVS program is on, but time is not counting time; otherwise, lit if an SVS program is on.
19. **Single Needle On/Off** - Lit if single needle is on.

There are also two columns of bar-graph LEDs, one each for arterial and venous pressure. Only three LEDS can be lit in one of these bar-graphs at a time: two dim LEDs, to signify alarm limits for the pressure, and one bright LED, to signify the actual pressure value.

3. Membrane Switches

The membrane switches embedded in the Front Panel overlay are spring-loaded, momentary action, contact type switches. The membrane switch signals are connected to the Display Board through a flexible cable that plugs into Display Board connector P2. The Display Board simply buses these signals from connector P2 to P1. From P1, these signals are routed to the Motherboard through a short ribbon cable assembly. The membrane switch signals are then routed to the appropriate boards through the Motherboard.

The Power ON/OFF membrane switch, when pressed, grounds the PWR-ON signal to the Power Logic Board. This will cause the Power ON/OFF circuit on the Power Logic Board to change state. The current state of this circuit will determine whether pressing the Power ON/OFF membrane switch turns the main power ON or OFF.

The Flow ON/OFF membrane switch, when pressed, grounds the FL-SW signal to the Actuator Board. This will cause the Actuator Board to turn the Dialysate Flow ON or OFF, depending on the current state and the current operational mode.

The remaining membrane switches are scanned by the Functional Board, using a 74C922 4 x 4 Matrix Key Press Detector. The 74C922 will detect the membrane switch that was pressed and issue an interrupt to the 80C31 Microcontroller. The data read from the 74C922 in conjunction with the current operational mode will be used by the 80C31 to determine the action that will be taken in response to the membrane switch pressed.

There are 15 keys on the front panel. 13 of them cause a keyboard interrupt to occur; debouncing is handled in the interrupt, and the key may be passed on to the section of the program that will process it. 1 key (the Power On/Off key) can be read using an input pin (NOT-PRESSING-SWITCH). 1 key (the Flow key) cannot be read by the functional board (its function is handled by the actuator board).

The functions of the keys are as follows:

1. Prime

   This key can be used to start priming at any time (even during the no-program state) providing that blood is not sensed (BLOOD-NOT-SENSED high) and there is a level detector alarm (NO-LEVEL-DETECTOR-ALARM low). If one of those conditions is false, an appropriate message is displayed; otherwise, priming begins. If priming is already active, this key turns it off.

2. Reset

Pressing the Reset key clears clearable alarms. If there is a new-limits messages displayed (i.e. “NEW TMP LIMITS?”), pressing Reset for one second will cause the limits in question to close around the pressure value, and an appropriate message to be displayed (i.e. “NEW TMP LIMITS CHOSEN”). If no such message is displayed, pressing Reset for one second will re-center arterial and venous limits. If a soft limit arterial, venous, or TMP alarm exists, pressing Reset will cause a new-limits message to be displayed (i.e. “NEW TMP LIMITS?”). If a hard limit TMP alarm exists, pressing Reset will cause the message “ADJUST TMP?” to be displayed, which is another kind of new-limits message; when Reset is pressed again for one second, TMP is adjusted artificially, with the message “ADJUSTING TMP” displayed.

3. Mute

Mute alarm and warning sounds for 2 minutes, if not already muting and an alarm or warning exists. Outside of dialysis, allow muting of warning sounds. Note that muting is turned off whenever a new alarm occurs. Note that fatal alarms (which shut down the machine) cannot be muted.

4. UF On/Off

If the user has turned UF on (though it may be interrupted by an alarm) this key turns it off. If UF is off, and the machine is in dialysis, and there are no blood alarms and no UF Pump Alarm, and there is no Maximum UF Rate Warning, and the UF rate selected is at least 10 ml/hour, then pressing this key will turn UF on.

5. Test

This key is used to initiate the test, if the test is not active, and the machine is in dialysis, and there are no alarms, and the dialysis lines are on the shunt (DIALINE_OFF_SHUNT low) and blood is not sensed (BLOOD_NOT_SENSED high) and UF is not on, and an SVS program is not running, and single needle is off. If the test is active, but has stopped with an alarm for a failed test step, pressing the Test key once will mute the alarm sound, and pressing it again will advance to the next test step. If in T&C mode, and in the test, and there is no failed step currently, pressing the Test key will briefly display the number of the times the test has cycled through all of its steps.

6. Sodium Variation

This key turns on the sodium variation program, if it is off, and the machine is in dialysis, and the program time is non-zero, and flow is on (FLOW-STOP-ACKNOWLEDGE low). This key interrupts a sodium variation program if it is on, and turns it back on if it has been interrupted.

7. Override

   In dialysis, if a blood leak alarm is the only blood alarm, this key can be used to override the alarm for up to 3 minutes. If the override feature is already active, pressing this key will turn it off. If this key is held in for one second, and the user has selected the "Spread Limits" option in calibration, then arterial and venous limits will be centered around the pressure values, with a window width of 15 LEDs, for 30 seconds.

8. Single Needle

   If dialysis is off, and the single needle function is off, and the venous pump is plugged in (VENOUS-BLOOD-PUMP-IN-SINGLE-NEEDLE high) then pressing this key will turn the single needle function on. If single needle is already on, pressing this key will turn it off.

9. Up

   This key is generally used to move the arrow around the screen, and, when editing a variable, to raise its value.

10. Down

    This key is generally used to move the arrow around the screen, and, when editing a variable, to lower its value. In dialysis, the key is held in one second to clear the Blood Volume Processed (BVP) or UF Removed (when editing the respective field).

11. Set

    Press Set to edit the selected setting, or to stop editing and save the chosen value. The Set key is also used as part of the procedure for Chemical Rinse, Chemical Dwell, and Acid Rinse.

12. Left

    This key is used to move the arrow around the screen.

13. Right

    This key is used to move the arrow around the screen.

14. Debug

    This "key" (generated by pressing up then mute then down within one second) causes the debugging screens to be brought up.

4. Plasma Display Control

The Plasma Display is a 128 x 64 pixel display driven at a field scan rate of about 98Hz. This scan rate provides a flicker free display that won't exhibit any visual stroboscopic effects with the ambient artificial lighting due to the AC line frequency. An HD61830B Display Controller (U6) and three PLDs control the Plasma Display, with the display data stored in the CY7C185 BK Byte SRAM (U7).

The main clock for the Plasma Display Control circuit is PCLK, an 800KHz clock generated by the divide by 10 counter (comprised of outputs DQ0, DQl, DQ2, and PCLK) in PLD PCLKGENA (U4) from the 8MHz clock CLK8M generated by crystal oscillator X01. The HD61830B Display Controller (U6) generates most of the signals driving the Plasma Display, with additional timing signals generated by PLD PCLKGENB (U3). The timing and control of the Plasma Display is dependent on how the Internal Registers of U6 are set.

The MPU on the Functional Board can write or read data in the Display RAM at the address location defined by U6 Internal Registers A and B (Cursor Address). Since U6 is continuously reading a block of memory to drive the display, all data transfers between the MPU and the Display RAM must be synchronized to occur between the Sequential Display Data Output cycles that transfer data from the Display RAM to the Plasma Display.

For a Display Data Write cycle, the data is first written to U6 Internal Register C (Write Display Data). U6 will then write the data in this register to the Display RAM between the Sequential Display Data Output cycles, and then increment the Cursor Address.

For a Display Data Read cycle, the data will be read from U6 Internal Register D (Read Display Data). At the end of the Data Read DLE* cycle, U6 will load the data at the current Cursor Address in the Display RAM to U6 Internal Register D between Sequential Display Data Output cycles and then increment the Cursor Address. As a result, the first Display Data Read cycle following an ALE* cycle will read a dummy byte from U6 Internal Register D. The actual data from the specified Display RAM location will be read during the next Display Data Read cycle, and subsequent Display Data Read cycles will read data from sequential memory locations in the Display RAM. Any ALE* cycle will cause the next Display Data Read cycle to read a dummy byte.

5. High Voltage Power Supply

This section applies to Display Board Assembly 190000 when used with Plasma Display P/N 370048. A Plasma Display operates similarly to a neon or fluorescent lamp, in that a high voltage applied across a gas filled cell will cause the gas to fluoresce. In this case, an array of 128 x 64 gas filled cells that are scanned by rows and columns are combined in one module for the Plasma Display used on the Front Panel. For this Plasma Display, the maximum power requirements are as follows:

1) +Vcc: +5.0VDC at 100mADC
2) +Vdd: +12VDC at 10mADC
3) +Vbb: +70VDC at 40mADC
4) -Vbb: -115VDC at 40mADC
5) +Vss: +12VDC (referenced to the -115VDC supply) at 15mADC

On the Plasma Display, the +70VDC and -115VDC are used on the columns and rows (respectively) to provide the 185VDC voltage differential required to turn ON the pixels. +Vcc is used by the input buffers and control logic, +Vdd is used by the CMOS logic controlling the +70VDC column drivers, and +Vss is used by the CMOS logic controlling the -115VDC row drivers.

While +Vcc and +Vdd are supplied by the Power Logic Board, +Vbb, -Vbb, and +Vss are generated on the Display Board from the +24VDC power supply. This is done with an LT1070 Switch Mode Power Supply Regulator (U26) and a pot-core transformer (Ti) with three secondary outputs. The secondary outputs are rectified by diodes D11, D12, and D13 with filtering by capacitors C38 through C43.

ACTUATOR BOARD

The main functions of the actuator board are to control the hydraulic system of the dialysis machine, communicate with the functional board and also monitor the system to determine if the machine is working properly. If not, it will send alarm(s) to the functional board through the communication and take corresponding action to the hydraulic system to make sure that the machine is absolutely safe.

1. Program Flow.

When the machine is turned on, it first goes through an initialization sequence using function main_init( ). Then it goes into an endless loop. All program activities happen in this loop as background tasks while waiting for the interrupt. Within this loop it first reads in all necessary hardware data such as: flow switch on/off, dial lines in/out, shunt door open/close, concentrate and bicarbonate wands in/out, bicarbonate and concentrate pump end of stroke signal, state of the dip switches, blood sensed signal, etc.. There is a 10 ms timer interrupt (T0_int) which controls the machine steps. If the 10 ms is not up, the program will update every valve, process the communication data coming from the functional board and update the data which will be sent to the functional board.

When the 10ms timer interrupt occurs (T0_int), it first resets the interrupt flag for the next interrupt, updates the balance chamber switch counter and the run time counter which remembers how long the machine runs, reads some ADC channels, and then if the machine is just started and the deareation pump steps have been received from the functional board, does the preparation for the hydraulic system (only once when the machine starts up).

After the preparation is done, the machine is in the NO PROGRAM state, which means the machine sets up the main menu waiting for a command from the functional board. Depending upon the command, the machine executes the dialysis program or one of the rinse/disinfect program or calibration program. Also the actuator board does redundant monitoring within this 10ms. The redundant monitoring checks bicarbonate and acetate pumps, checks the flow, the UF pump, the temperature and conductivity limits, the arterial, venous, and TMP pressure limits, monitors water alarms, monitors blood alarms, and shuts off the machine if a water alarm or blood alarm or actuator board EPROM CRC error occurs for a certain period of time. These alarms will be discussed in the following “alarm” section. Also the heater will be controlled based on different alarm conditions.

2. Alarms.

There are 25 alarms generated by the actuator board:

(1). FLOW_ERROR_REC
(2). FLOW_ERROR_INLET
(3). LOW_FLOW
(4). HIGH_FLOW
(5). FLOW_ERROR
(6). NO_WATER
(7). VALVE_ERROR
(8). VALVE_24_ERROR
(9). BLOOD_PUMP_FAIL
(10). UFP_ERROR
(11). BLOOD_SENSED
(12). HI_ART_ALARM
(13). LO_ART_ALARM
(14). HI_VEN_ALARM
(15). LO_VEN_ALARM
(16). HI_TEMP_ALARM
(17). LO_TEMP_ALARM
(18). COND_HI_ALARM
(19). COND_LO_ALARM
(20). HI_TMP_ALARM
(21). LO_TMP_ALARM
(22). CRC_ERROR
(23). SENDING_ERROR
(24). ACETATE_FAILED
(25). BICARB_FAILED

The condition to generate the alarm and action taken for the alarms are discussed below:

[1]. FLOW_ERROR_REC

A: Condition

To generate this alarm, it should have recirculation valve 29 open and valve 43 closed. If at balance switch counter reach 4.36 seconds the dialysis pressure at valve 43 opening is less than or equal to P_DIAL pressure mean reading 10 times(cycle) before it is greater than P_DIAL 10 times. Or if the start pressure sampled at balance switch counter reaches 0.64 second less than or equal to dialysate pressure mean reading 10 times before it is greater than dialysate pressure 10 times the FLOW_ERROR_REC will be generated.

B: Action

This is one of the flow errors. After the actuator board detects this error it will issue FLOW_ERROR_REC and FLOW_ERROR to the functional board for the alarm report (sound, display). The actuator board will turn the heater off.

[2]. FLOW_ERROR_INLET

A: Condition

When the float switch is on which means there is enough water in the water chamber so it will keep the water inlet valve closed until float switch is off, if for some reason the float switch is bad, the water inlet valve (valve 41) is kept closed for 3 balance chamber switch cycles and the machine runs in recirculation type of rinse, it will generate this alarm.

B: Action

This is one of the flow errors. After machine detects this error it will issue FLOW ERROR INLET and FLOW ERROR to the functional board for the alarm report (sound, display). The actuator board will turn the heater off.

[3]. LOW_FLOW

A: Condition

If the balance switch counter reaches EIGENTAKT-OVERLAPP for 5 times in the row during the dialysis which means the balance chamber switches too slowly, the machine will generate this alarm.

B: Action

This is one of the flow errors. After machine detects this error it will issue LOW_FLOW and FLOW_ERROR to the functional board for the alarm report (sound, display). The actuator board will turn the heater off.

[4]. HIGH_FLOW

A: Condition

If the balance switch counter is between 1.8 seconds and 1.9 seconds when it already reaches the threshold and switch the balance and chamber 5 times in the row which means that it switches too quickly. The machine will generate the HIGH_FLOW alarm.

B: Action

This is one of the flow errors. After machine detects this error it will issue HIGH_FLOW and FLOW_ERROR to the functional board for the alarm report (sound, display). The actuator board will turn the heater off.

[5]. FLOW_ERROR

A: Condition

FLOW_ALARM is the general alarm for the 4 kinds alarm mentioned above. Any one of FLOW_ERROR_REC, FLOW_ERROR_INLET, LOW_FLOW and HIGH_FLOW occurs will also generate a FLOW_ERROR

B: Action

After machine detects this error it will issue FLOW_ERROR to the functional board for the alarm report (sound, display). The display will be over written by specific flow alarm message in a very short time. The actuator board will turn the heater off.

[6]. NO_WATER

A: Condition

If the water inlet valve open exceed the defined maximum time, the NO_WATER alarm will occur. The maximum time for different kind of operations are:

Regular	5	seconds.
Preparation	30	seconds.
Rinse	10	seconds.
Calibration	30	seconds.

Any time if there is enough water in the tank (WATER_IN_SENS is high) or water inlet valve open time less than maximum time this alarm will be cleared.

B: Action

Turn the heater off.

[7]. VALVE_ERROR

A: Condition

If the hardware pin VALVE_OK (CTI3) is high this means all the valves are ok. If at any time this line keep low for 1 second the VALVE_ERROR alarm will be set up. This alarm will be reset any time when the VALVE_OK line goes to high.

B: Action

None now from the actuator board side.

[8]. VALVE_24_ERROR

A: Condition

VALVE 24 is Dialyzer Valve 1. There are 3 separate situations to determine if this valve working correct if the machine is not in the calibration mode.

a: If this is a water alarm, (water alarm include HI_TEMP_ALARM, LO_TEMP_ALARM, COND_HI_ALARM, COND_LO_ALARM) and flow is on, valve 24 should be closed. If the valve is on, based on an input hardware state for 5 seconds VALVE 24 ERROR will occur.

b: If the actuator board receives DIALYSATE ALARM from functional board, it should go into bypass closing valve 24. If valve 24 keeps open for 5 seconds VALVE_24_ERROR will occur.

c: If the actuator board software sets valve 24 to open but the input hardware data indicates the valve 24 still closed for 250ms, a VALVE_24_ERROR will be occur.

This alarm is not self clearing.

B: Action

After actuator board generates this alarm, it waits for 1 second to communicate with functional board to display the alarm message on the screen and then the machine will be shut off by having the watchdog to kill the 24V.

[9]. BLOOD_PUMP_FAIL

A: Condition

When BLOOD_SENSED and machine is not in calibration, if it has one of the following alarm, HI ART_ALARM, LOW_ART_ALARM HI_VEN_ALARM, LW_VEN_ALARM the blood pump should stop. If the blood pump still runs for 10 seconds the BLOOD_PUMP_FAIL will be generated. Also if the alarm is HI_TMP_ALARM or LO_TMP_ALARM if the blood pump keep running for 15 seconds the BLOOD_PUMP_FAIL will be generated. One thing must be mentioned here is this alarm is not self clearable. After one second of this alarm detected (one second is for communication to functional board) the machine will be shut of f by having the watch dog to kill 24V.

B: Action

Shut the machine down.

[10]. UFP_ERROR

A: Condition

If hardware pin P1.5 (RT2) is low the UF pump has a problem. If in 1 second this bit is low for more than 300ms, the UFP_ERROR alarm will occur.

B: Action

None from actuator board side.

[11]. BLOOD_SENSED

A: Condition

The ODSA optical signal is sampled 4 times every 2.5ms per 10ms. If all 4 samples are 0 for 10 continuously 10ms period (debouncing) then the BLOOD_SENSED will be set to 1. If one of the 4 samples is 1 for 10 continuously 10ms period the BLOOD_SENSED will be reset to 0.

B: Action

If the BLOOD_SENSED and machine is running in dialysis or rinse the blood pump will be monitored. (see BLOOD_PUMP_FAIL above) In fact this bit is not an alarm signal.

[12]. HI_ART_ALARM

A: Condition

There are 2 sets of arterial high and low limits depending upon dip switch 3 on the functional board which has been sent to the actuator board. If the switch is 1, the limit is -80 to 500, otherwise -300 to 280 mmHg. The formula used to calculate the arterial pressure is art_pressure=200*(art_adc_value-art_0)/(art_200-art_0) where art_adc_value is the mean reading from ADC channel of arterial pressure, art_0 and art_200 are the two reference ADC values at arterial pressure 0 and 200. The 10 running average of arterial pressure will be used to determine the alarm. If the arterial pressure is greater than high limit (500 or 280). The HI_ART_ALARM will be generated. This alarm is self clearable.

B: Action

Goes to bypass, also see BLOOD_PUMP_FAIL.

[13]. LO_ART_ALARM

A: Condition

See HI_ART_ALARM, if the calculated arterial pressure is less than the low limit (-80 or -300), the LO_ART_ALARM will be generated. This alarm is self clearing.

B: Action

Goes to bypass, also see BLOOD_PUMP_FAIL.

[14]. HI_VEN_ALARM

A: Condition

The formula used to calculate the venous pressure is ven_pressure=400* (ven_adc_value-ven_0)/(ven_400-ven_0) The ven_adc_value is read from the ADC channel, and ven_400, ven_0 are reference ADC value for venous pressure 400 and 0 which come from the functional board. If the 10 running average for venous pressure is over the high limits which is 500 the machine will generate the HI_VEN_ALARM. This alarm is self clearing.

B: Action

Goes to bypass, also see BLOOD_PUMP_FAIL.

[15]. LO_VEN_ALARM

A: Condition

See HI_VEN_ALARM. If calculated venous pressure average is less than low limit which is -80. A LO_VEN_ALARM will be generated. This alarm is self clearing.

B: Action

Goes to bypass, also see BLOOD_PUMP_FAIL.

[16]. HI_TEMP_ALARM

A: Condition

If the machine is not in the hot rinse, it will check the temperature every second. The formula used to calculate the temperature is: temp=340+(70*(adc_temp_value-low_temp)/(high_temp-low_temp)) where the high temp and low temp are the reference temp value at 41°C and 34°C received from the functional board. If the temperature is over 41°C, a HI_TEMP_ALARM will be issued. This alarm is self clearing.

B: Action

Turn the heater off. Goes to bypass. Also see VALVE_24_ERROR.

[17]. LO_TEMP_ALARM

A: Condition

If the calculated temperature is less than 33°C, a LO_TEMP_ALARM will be generated. The alarm is self clearing.

B: Action

Goes to bypass. Also see VALVE_24_ERROR.

[18]. COND_HI_ALARM

A: Condition

If the flow is on the conductivity will be calculated every second. The formula used to calculate the conductivity is very complicated so it will not be listed here. The calculation is based upon two values received from functional board called cond_ref and cond_offset. Also the conductivity is calculated using the frequency in Hz which is counted using T1 timer/counter. The calculation also considers the temperature compensation. If the calculated conductivity is over 16.0 a COND_HI_ALARM will be reported. This alarm is self clearing.

B: Action

Goes to bypass. Also see VALVE_24_ERROR.

[19]. COND_LO_ALARM

A: Condition

If the calculated conductivity is less than 13.0, a COND_LO_ALARM will be issued. This alarm is self clearing.

B: Action

Goes to bypass. Also see VALVE_24_ERROR.

[20]. HI_TMP_ALARM

A: Condition

The TMP is checked every second. It uses the battery value sent by functional board, ADC value at pressure 0 dial0 and at pressure 250 dial250, to compute the dialysate pressure. The TMP = venous pressure - dialysate pressure. The TMP value used to determine the alarm is running average of 100 samples. If the TMP average is greater than 520 the HI_TMP_ALARM will be generated. This alarm is self clearing.

B: Action

Machine goes to bypass. Also see BLOOD_PUMP_FAIL.

[21]. LO_TMP_ALARM

A: Condition

If calculated TMP running average is less than -60, the alarm LO_TMP_ALARM will be generated. This alarm is self clearing.

B: Action

Machine goes to bypass. Also see BLOOD_PUMP_FAIL.

[22]. CRC_ERROR

A: Condition

If the EPROM on the functional board fails the CRC_ERROR alarm will occur.

B: Action

After this alarm generated, the actuator board waits 20 seconds before communicating with functional board to display the error message on the screen and then shuts off the machine by killing the watch dog.

[23]. SENDING_ERROR

A: Condition

If the communication between functional board and actuator board is not as expected, the SENDING_ERROR alarm will occur to inform the functional board.

B: Action

This is not a real alarm because it is not displayed for telling the user. It is set so that functional board can recover from a communication error.

[24]. ACETATE_FAILED

A: Condition

There are two ways to generate ACETATE_FAILED alarm.

a: After the second time the machine detects no end of stroke for acetate pump by reading a hardware line. If the pump move towards the end of stoke at more than 500 steps for 3 times in the row in 10 minutes, the NO_EOS will be reported. After the second time in the row if the machine detects the end of stroke signal, but the pump moves from end of stroke for more than 100 steps 3 times in 10 minutes the ALWAYS_EOS will be generated. Either one of NO_EOS and ALWAYS_EOS happen will cause the ACETATE_FAILED

b: If machine is not at the start of changing acetate pump step and not the first time no end of stroke or always end of stroke caused by condition (a) above(ACETATE_FAILED not set), it will calculate the sum of steps off of 5 most recent strokes except the first time off 10 steps in one stroke in 10 minutes. Whenever the sum is over 10 strokes the ACETATE_FAILED alarm will occur. Generally it takes 5 strokes to clear this alarm.

B: Action None.

[25]. ACETATE_FAILED

A: Condition

There are two ways to generate BICARB_FAILED alarm.

a: After the second time if the machine detects no end of stroke for the bicarb pump by reading a hardware line. If the pump moves toward the end of stoke at more than 500 steps for 3 times in the row in 10 minutes, the NO_EOS will be reported. After the second time in the row if the machine detects the end of stroke signal, but pump move from end of stroke for more than 100 steps 3 times in 10 minutes the ALWAYS_EOS will be generated. Either one of NO_EOS and ALWAYS_EOS happen will cause the BICARB_FAILED alarm to occur.

b: If machine is not at the start of changing bicarbonate pump steps, and not the first time no end of stroke or always end of stroke caused by condition a above(BICARB_FAILED not set), it will calculate the sum of steps off of 5 most recent strokes except the first time off 10 steps in one stroke in 10 minutes. Whenever the sum is over 10 strokes the BICARB_FAILED alarm will occur. Generally it takes 5 strokes to clear this alarm.

B: Action

None.

3. ADC channels.

There are 8 A to D channels:

(1). Channel 0: Read in Chamber Full Switch.
(2). Channel 1: Read in dialysate pressure.
(3). Channel 2: Read in arterial pressure.
(4). Channel 3: Read in venous pressure.
(5). Channel 4: Read in temperature.
(6). Channel 5: Read in blood leak voltage.
(7). Channel 6: Read in 1.3V reference. (on Rev. A actuator boards this channel monitored 12 volts)

4. Dip-Switch settings.

There are 4 dip switches on the actuator board.

Dip switch 1: If it is on the position OPEN (logically 1) the actuator board will use chamber full switch (CFS) to determine the balance and chamber switch, otherwise it will use the current rise pulse to switch the balance and chamber.

Dip switch 2: If it is on the position OPEN (logically 1) the functional board will use more accurate way to test the 12 V power, otherwise it will test the 12V in the old way.

Dip switch 3: Unused.

Dip switch 4: Unused.

FUNCTIONAL BOARD

There are 8 dip switches on the functional board, which can be used to select user options. THESE SWITCHES MUST ONLY BE CHANGED WITH THE POWER OFF! Changing them with the power on will not have the desired effect, and may result in a loss of calibration data. The dip switch settings are as follows:

1. On to enable the on line pressure holding test.
2. On for machine power off after heat disinfect finishes.
3. On for arterial post pump drip chamber (off for pre pump).
4. On for no audible alarm if blood not sensed and dialysate lines are on the shunt. (When lines are removed from shunt, there will be audible alarms).
   Off for no audible if blood not sensed. (Lines on or off the shunt).

5&6. These two switches determine the maximum UF rate, based on one of four combinations:

5 off,	6 off	maximum rate 1000 ml/hour
5 on,	6 off	maximum rate 2000 ml/hour
5 off,	6 on	maximum rate 3000 ml/hour
5 on,	6 on	maximum rate 4000 ml/hour

7. On for T&C mode. This has the following effects:

    1. UF rate can be run without a goal or time.
    2. UF goal and time display “N/A”.
    3. RTD is not copied from UF time.
    4. TMP limits are always spread.
    5. Arterial and Venous limits are always spread.
    6. The test repeats after finishes (continually).
    7. Rinse times may be set for less than 10 minutes.
    8. Calibrations do not need to be done to enter dialysis.
    9. The conductivity calibration values are not checked.

8. On to limit the high arterial limit to -9 mmHg if blood is sensed.

I/O Pins

There are 24 input and 24 output pins on the Functional Board.

These pins are known by at least 3 different names each: the name on the schematic, the name on the debug screens, and the name used in this document. The name in this document is preferred, as it is the most explanatory. Below is a list relating these names, also including the pin numbers on the 2008H functional board.

Schematic	Pin	Debug	In This Document
UF-PULSE-WATCH	A29	UFPULS	UF-PULSED-HI
DIALINE	A30	LINOFF	DIALINE-OFF-SHUNT
EMPTYING	A31	!EMPTY	NOT-EMPTYING
FLOW-OUT	C1	FLWOUT	FLOW-OUT
FLOW-STOP-ACKN	C2	FLWSTP	FLOW-STOP-ACKNOWLEDGE
BYP-CURRENT	C3	UNUSED	UNUSED
LEVEL-UP	C4	LD UP	LEVEL-DETECTOR-UP
LEVEL-DOWN	C5	LD DWN	LEVEL-DETECTOR-DOWN
SW-ON	A8	SW PNL	SWITCH-ON-BY-PANEL
SW-OFF	A9	!SWITC	NOT-PRESSING-SWITCH
TRIAC-WATCH	A10	TRIAC	TRIAC-ON
EX-ALM	A11	!EXTAL	NO-EXTERNAL-ALARM
HEP-ALARM	C25	!HEPAL	NO-HEPARIN-ALARM
SN	C26	!SNGNE	SINGLE-NEEDLE-STOPPED
BPUS	C27	!BPSTP	NO-BLOOD-PUMP-STOP-ALARM
ADKS	C28	VEN BP	VENOUS-BLOOD-PUMP-CONNECTED
BIC-W-REED	A3	BICOUT	BIC-WAND-OUT-OF-PORT
AIR-WATCH	A7	!AIR	AIR-NOT-SENSED
OD	C23	!BLOOD	BLOOD-NOT-SENSED
LDA1	C24	!LD AL	NO-LEVEL-DETECTOR-ALARM
COVER	C6	CVRCLS	SHUNT-COVER-CLOSED
DIAL-VLVE	C7	DIAVLO	DIALYSIS-VALVE-OPEN
SUPPL-M	A21 PP2	V12 OK	12-VOLTS-OK
CONC-W-REED	A21	ACIOUT	ACID-WAND-OUT-OF-PORT
SNST	C20	SNG NE	SINGLE-NEEDLE-ENABLED
COND-RES -ON	A6	!CNDRE	CONDUCTIVITY-RESISTOR-OFF
VENT	C15	VNTVLO	VENT-VALVE-OPEN
CLAMP	C16	CLAMPO	VENOUS-CLAMP-OPEN
CLRAL	C17	CLR AL	CLEAR-ALL-ALARMS
BSST	C18	!BPSTP	BLOOD-PUMP-SYSTEM-STOP-OFF
BPST	C19	BPSPEC	BLOOD-PUMP-SPECIAL-CONTROL
COND-CAL	A5	!CNDCA	CONDUCTIVITY-CALIBRATION-OFF
WARNING	A14	WARNSO	WARNING-SOUND-ON
RINSE	A22	RINSE	RINSE-ON
SEL-COND	A23	!FLOW	FLOW-OFF
BYP-OFF	A24	!RELPR	RELEASE-PRESSURE-OFF
DIALYSATE-ALARM	A25	!DIAAL	DIALYSATE-ALARM-OFF
FILL	A26	!FILL	FILL-OFF
AIR-SEPERATION	A28		COMM-ERR
UF-PULSE	A27	UFPULS	UF-PULSE-HI
EMERG-HT-OFF	A15	HEAT	HEAT-ON
NURSE-CALL	A16	NURSEC	NURSE-CALL-ON
DIAL-OUT	A17		UNUSED-OUTPUT
TW-RESET	A18	TRIWDR	TRIAC-WATCHDOG-RESET
DAC-A0	A19	DACAD0	DAC-ADDRESS-0
DAC-A1	A20	DACAD1	DAC-ADDRESS-1
HOT-RINSE	C14	!DISHE	DISINFECT-HEAT-OFF
ALARM	A13	AIM SO	ALARM-SOUND-ON

The functions of the input pins are as follows:

UF-PULSED-HI	This pin goes high for a brief period after a UF pulse is generated.
DIALINE-OFF-SHUNT	This pin is low if both the red and blue tubes are on the shunt; otherwise it is high.
NOT-EMPTYING	This pin is low if the red tube is off the shunt and the blue tube is on the shunt; otherwise it is high.
FLOW-OUT	This pin toggles at a steady rate, based on the flow rate.
FLOW-STOP-ACKNOWLEDGE	High if flow is stopped. Note that several different mechanisms determine whether or not flow is actually on; this is only one of them (so flow could be off with this pin low).
UNUSED	This pin is not currently used.
BIC-WAND-OUT-OF-PORT	High if the bicarb wand is out of the port.
AIR-NOT-SENSED	Low if air is sensed.
BLOOD-NOT-SENSED	Low if blood is sensed (optical detector dark).
SHUNT-COVER-CLOSED	High if the shunt cover is closed.
DIALYSIS -VALVE-OPEN	High if the dialysis valve is open.
ACID-WAND-OUT-OF-PORT	High if the acid wand is out of the port.
LEVEL-DETECTOR-UP	High if the chamber adjust switch is held up.
LEVEL-DETECTOR-DOWN	This pin always reads low (unused).
SWITCH-ON-BY-PANEL	Unknown power key function.
NOT-PRESSING-SWITCH	Low if the power on/off key is held in.
TRIAC-ON	Low if the heater is on for more than 1.6 seconds.
NO-EXTERNAL-ALARM	Low if the (unused) external alarm occurs.
NO-HEPARIN-ALARM	Low if a heparin pump alarm occurs.
SINGLE-NEEDLE-STOPPED	High during single needle will close the venous clamp.
NO-BLOOD-PUMP-STOP-ALARM	Low if a blood pump stop alarm occurs.
VENOUS -BLOOD-PUMP-CONNECTED	High if the venous blood pump is plugged in.
NO-LEVEL-DETECTOR-ALARM	Low if a level detector alarm occurs.
12-VOLTS-OK	Low if 12 volts is not within acceptable limits.

The functions of the output pins are as follows:

VENT-VALVE -OPEN	Set high to open the vent valve (during prime).
VENOUS-CLAMP-OPEN	Set high to open the venous clamp.
CLEAR-ALL-ALARMS	Pulsed to clear alarms from modules.
BLOOD-PUMP-SYSTEM-STOP-OFF	High to run the blood pump.
BLOOD-PUMP-SPECIAL-CONTROL	High to run the blood pump at a fixed speed (used for the chamber adjust switch).
RINSE-ON	High to turn rinse on.
FLOW-OFF	Low to turn flow on.
RELEASE-PRESSURE-OFF	Low to make the actuator board release pressure (used for Adjusting TMP).
DIALYSATE-ALARM-OFF	Set low to tell the actuator board to put the machine into bypass.
FILL-OFF	Set low to go into a filling program.
UF-PULSE-HI	Pulsed to generate one UF stroke.
SINGLE-NEEDLE-ENABLED	Set high if the user selects the single needle option.
CONDUCTIVITY-RESISTOR-OFF	Set high or low to select the resistor used for conductivity calibration.
CONDUCTIVITY-CALIBRATION-OFF	Set low for conductivity calibration values (instead of the actual conductivity).
HEAT-ON	Set high to turn the heater relay on.
TRIAC-WATCHDOG-RESET	Pulsed to reset the triac watchdog.
DISINFECT-HEAT-OFF	Set low to generate the high temperature used in heat-disinfect.
WARNING-SOUND-ON	Set high to make the warning sound.
ALARM-SOUND-ON	Set high to make the alarm sound.
NURSE-CALL-ON	Set high to activate the nurse call.
DAC-ADDRESS-0 / DAC-ADDRESS-l	These two pins are used to determine which DAC value to write to:

DAC1	DAC0	
0	0	temperature set point
0	1	blood dimness calibration
1	0	blood leak calibration
1	1	temperature calibration

TEST BOARD

The operational description for the 2008H test program.

A. Initial setup

1. Start the test in dialysis and alarm free condition. The dialysate connectors must be on the shunt and the shunt door closed. Also the ultrafiltration pump must be off.

2. Set venous and arterial to atmospheric pressure by disconnecting the blood lines to these input pressure ports.

3. Hold in the test keypad for 1 second.

B. The test

1. During the test, there is a message displayed in the status line giving the test step that is being performed.

2. Observe the appropriate led for each test.

(1) Level detector red alarm led. Note: the alarm led for the level detector will be brief.

(2) Blood leak detector red alarm led, the blood leak detector yellow normal alarm led, and for a brief time the blood leak detector yellow minor alarm led.

(3) Arterial upper hard limit detection: notice a red alarm and upper arrow led.

(4) Arterial lower hard limit detection: notice a red alarm and lower arrow led.

(5) Arterial upper auto-limit (automatically adjustable limit, soft) detection: notice a red alarm and upper arrow led.

(6) Arterial lower auto-limit (soft) detection: notice a red alarm and lower arrow led.

(7) Venous upper hard limit detection: notice a red alarm and upper arrow led.

(8) Venous lower hard limit detection: notice a red alarm and lower arrow led.

(9) Venous upper auto-limit (soft) detection: notice a red alarm and upper arrow led.

(10) Venous lower auto-limit (soft) detection: notice a red alarm and lower arrow led.

(11) TMP upper hard limit detection: notice the red alarm led.

(12) TMP lower hard limit detection: notice the red alarm led.

(13) TMP upper auto—limit (soft) detection: notice the red alarm led.

(14) TMP lower auto—limit (soft) detection: notice the red alarm led.

(15) Battery test.

(16) Optical detector test: notice the venous pressure limits shift, creating a lower venous alarm.

(17) Temperature upper auto-limit (soft) detection: notice the red alarm led and the yellow bypass led.

(18) Temperature lower auto-limit (soft) detection: notice the red alarm led and the yellow bypass led.

(19) Temperature upper hard limit detection: notice the red alarm led and the yellow bypass led.

(20) Temperature lower hard limit detection: notice the red alarm led and the yellow bypass led.

(21) Conductivity upper auto-limit (soft) detection: notice the red alarm led and the yellow bypass led.

(22) Conductivity lower auto-limit (soft) detection: notice the red alarm led and the yellow bypass led.

3. If any test step fails, the appropriate failure message is displayed. The alarm tone is turned on. Press TEST key once to turn off the alarm tone, and again to continue with the rest of the test program.

4. When the test program is over, the message “TEST COMPLETE” is displayed. This message can be cleared by pressing the “RESET” keypad.

The Functional Description for the 2008H Test Steps

Overview:

The FP (functional processor board) monitors the front panel test key and the status of the 2008H before it communicates with the TP (test processor board) to begin the test. To begin a test, the following condition must be present:

(1) the 2008H is alarm free,

(2) the dialysis lines is in the shunt,

(3) the UF operation is off, and

(4) the (od) optical detector does not sense blood.

Three lines are used for communication between the FP and the TP (test processor). These are:

(1)	TP --> FP	P3.2	Counter / Clear alarms pulse,
(2)	TP <-- FP	P1.1	Test allowed,
(3)	TP --> FP	P1.0	Test released.

The TP begins the test by monitoring a clear bit from port P1.1. The TP causes the machine to go into an alarm condition. When the TP monitors the blood pump off, the TP restores the 2008H to an alarm free condition and sends a high low P3.2 counter/clear alarms pulse to the FP. The FP disables the TP by setting P1.1 high and the FP clears all the alarms. The next test step begins when P1.1 is cleared. When the last test step is complete the TP clears P1.0 and the FP is free to run the 2008H in dialysis.

Test step 1: Test the level detector.

The TP sets LDSA signal (PP1 A15 on the TP) to 5V. This causes the level detector to reduce the ultrasonic signal across the level detector by 1/3. The level detector reacts by closing the clamp and sending an alarm condition to the FP. The FP shuts off the blood systems and turns the level detector alarm led on. The TP monitors the clamp close and the blood pump off. TP sends counter/clear alarms pulse to the FP. Alarms are cleared and the FP and TP are ready for the next test.

Test step 2: Test the blood leak detector.

The TP detunes the blood leak detector. The blood leak detector reacts by reducing the output signal below the normal alarm threshold. The blood leak detector normal led flashes. FP reacts by closing the clamp and shutting off the blood pump. FP monitors the blood pump stopped. TP sends counter/clear alarms pulse to the FP. Alarms are cleared and the FP and TP are ready for the next test.

Test step 3: Detunes the arterial pressure transducer to the upper hard limit.

The TP sets the detuning DAC to 0V and then turns on the CMOS switch. The zero adjustment for the arterial pressure transducer is pulled low. Using the equation of the circuit Vout = f(gain)*Vgain -f(offset)*Voffset + 5V, a low to the offset adjustment causes a Vout considerably above 5V. The FP along with the ADC on the sensor board measures this detuned arterial pressure of over 350mmHg. The FP reacts to the upper hard limit alarm by turning off the blood pump. The TP senses the blood pump off. The TP turns the CMOS switch off. The TP sends a counter/clear alarms pulse to the FP. Alarms are cleared and the FP and TP are ready for the next test.

Test step 4: Detunes the arterial pressure transducer to the lower hard limit.

The TP sets the detuning DAC to 10V and then turns on the CMOS switch. The 0 adjustment for the arterial pressure transducer is pulled high. Using the equation of the circuit Vout = f(gain)*Vgain - f(offset)*Voffset + 5V, a high to the offset adjustment causes a Vout considerably below 5V. The FP along with the ADC on the sensor board measures this detuned arterial pressure of under -300mmHg. The FP reacts to the lower hard limit alarm by turning off the blood pump. The TP senses the blood pump off. The TP turns the CMOS switch off. The TP sends a counter/clear alarms pulse to the FP. Alarms are cleared and the FP and TP are ready for the next test.

Test step 5: Detunes the arterial pressure transducer to the upper auto-limit.

The TP sets the detuning DAC to a value between 1V and 4V. The TP then turns on the CMOS switch. The 0 adjustment for the arterial pressure transducer is pulled low. Using the equation of the circuit Vout = f(gain)*Vgain - f(offset)*Voffset + 5V, a low to the offset adjustment causes a Vout above 5V. The FP along with the ADC on the sensor board measures this detuned arterial pressure of around 200mmhg. After 5 seconds, the FP reacts to the upper auto-limit alarm by turning off the blood pump. The TP senses the blood pump off. The TP sends a counter/clear alarms pulse to the FP. Alarms are cleared, the auto-limits are set around this new actual arterial pressure and the FP and TP are ready for the next test.

Test step 6: Detunes the arterial pressure transducer to the lower auto-limit.

The TP turns off the CMOS switch. Arterial pressure returns to 0 mmHg. After 5 seconds, the FP reacts to the lower auto-limit alarm by turning off the blood pump. The TP senses the blood pump off. The TP turns the CMOS switch off. The TP sends a counter/clear alarms pulse to the FP. Alarms are cleared and the FP and TP are ready for the next test.

Test step 7: Detunes the venous pressure transducer to the upper hard limit.

See test step 3.

Test step 8: Detunes the venous pressure transducer to the lower hard limit.

See test step 4.

Test step 9: Detunes the venous pressure transducer to the upper auto-limit.

See test step 5.

Test step 10: Detunes the venous pressure transducer to the lower auto-limit.

See test step 6.

Test step 11: Detunes the dialysate pressure transducer to the upper TMP hard limit.

See test step 3.

Test step 12: Detunes the dialysate pressure transducer to the lower TMP hard limit.

See test step 4.

Test step 13: Detunes the dialysate pressure transducer to the upper TMP auto-limit.

See test step 5.

Test step 14:Detunes the dialysate pressure transducer to the lower TMP auto—limit.

See test step 6.

Test step 15:Battery test.

The TP sets TEST-BAT signal (PP1 C14 on the TP) to 5V. This causes a load to be connected across the battery. The battery is now checked for a voltage greater then 7V. If this alkaline battery's voltage is above 7V the test passes. The TEST-BAT signal is removed. The TP sends counter/clear alarms pulses to the FP. Alarms are cleared and the FP and TP are ready for the next test.

Test Complete:

The alphanumeric display shows "TEST COMPLETE". The alphanumeric display can be cleared by pressing the "RESET" key.

SENSOR BOARD

A-to-D Channels

There are 16 a-to-d channels, numbered 0 to 15:

Channel	Volts	Name	Use
0	12.0	BLOOD-LEAK	Blood leak detector
1	12.0	BLOOD-DIMNESS	Blood dimness
2	12.0	ART-PRESSURE	Arterial pressure
3	12.0	VEN-PRESSURE	Venous pressure
4	12.0	DIAL-PRESSURE	Dialysate pressure
5	12.0	TEMPERATURE	Temperature
6	11.5	ART-DELIVERY	Arterial blood pump delivery rate
7	11.5	VEN-DELIVERY	Venous blood pump delivery rate
8	6.0	5-VOLTS	5 volts
9	30.0	24-VOLTS	24 volts
10	12.0	ART-KNOB	Arterial blood pump user setting
11	12.0	VEN-KNOB	Venous blood pump user setting
12	30.0	UNUSED	Unused
13	12.0	INLET	Inlet pressure (CFS)
14	0.0	UNUSED	Unused
15	12.0	DISIN-TEMP	Temperature during heat disinfect

Each of these values ranges from 0 to 255, with 255 representing the maximum voltage. Note that calibration further affects some values before they are displayed (except in diagnostics).

Conductivity is not an a-to-d channel, but is similar to one as far as the software is concerned. It is a 16-bit value.

S E C T I O N V

MODULE DESCRIPTION

SECTION V INDEX

ARTERIAL AND SINGLE NEEDLE BLOOD PUMP MODULE

HEPARIN PUMP MODULE

AIR/FOAM DETECTOR MODULE

BLOOD PRESSURE (BPS-08) MODULE

ARTERIAL AND SINGLE NEEDLE BLOOD PUMP MODULE

The plug-in module contains the operating and display elements, the pump with casing and rotor and the arterial or single needle pressure monitor transducer and connection for the pressure control and display.

Operating elements

Potentiometer: The pump is switched off at the left stop. Clockwise rotation increases the rate of delivery.

Potentiometer: Using a screwdriver, adjust the blood pump tubing ID compensation to match the pump segment you are using.

Display elements

Delivery rate: Digital display of the delivery rate.

Tube diameter: Set diameter of the pinup tube.

Alarm lamp: Lights up when the stoppage alarm is activated.

For reasons of personnel safety, the blood pump will run only when the door is closed. The pump rotor is removable for cleaning. If it should become necessary, because of power failure or line problem, the pump can be operated manually (in clockwise direction) with the built in handle. The pump tube section is held in place with two screw plungers.

The spring force of the rollers is designed in such a way, that the delivery pressure with the prescribed blood line system is limited to 2 bar (30 psi), which rules out ruptures of the blood lines from kinking or clogging. In the cold state, i.e. in the preparation phase, the delivery pressure is even less and because of the bloodline tolerances, the pump may not self prime with air.

The plug-in module is attached to the housing with two screws. The electrical connection to the monitor can be removed once the rear panel has been removed. The arterial or single needle pressure monitor connection is located beneath the blood pump.

Blood Pump Operating and Indicating Elements

Item 1: Delivery rate selector. Using the delivery rate selector, the pump can be switched of f and the delivery rate can be set to between 30 ml/min and 500 ml/min (w. tube diameter 7 mm).

Item 2: Tube diameter switch. The display of the delivery rate can be adjusted from 5 to 10 mm tube diameter.

Tube diameter display shows the set tube diameter in 0.5 mm steps

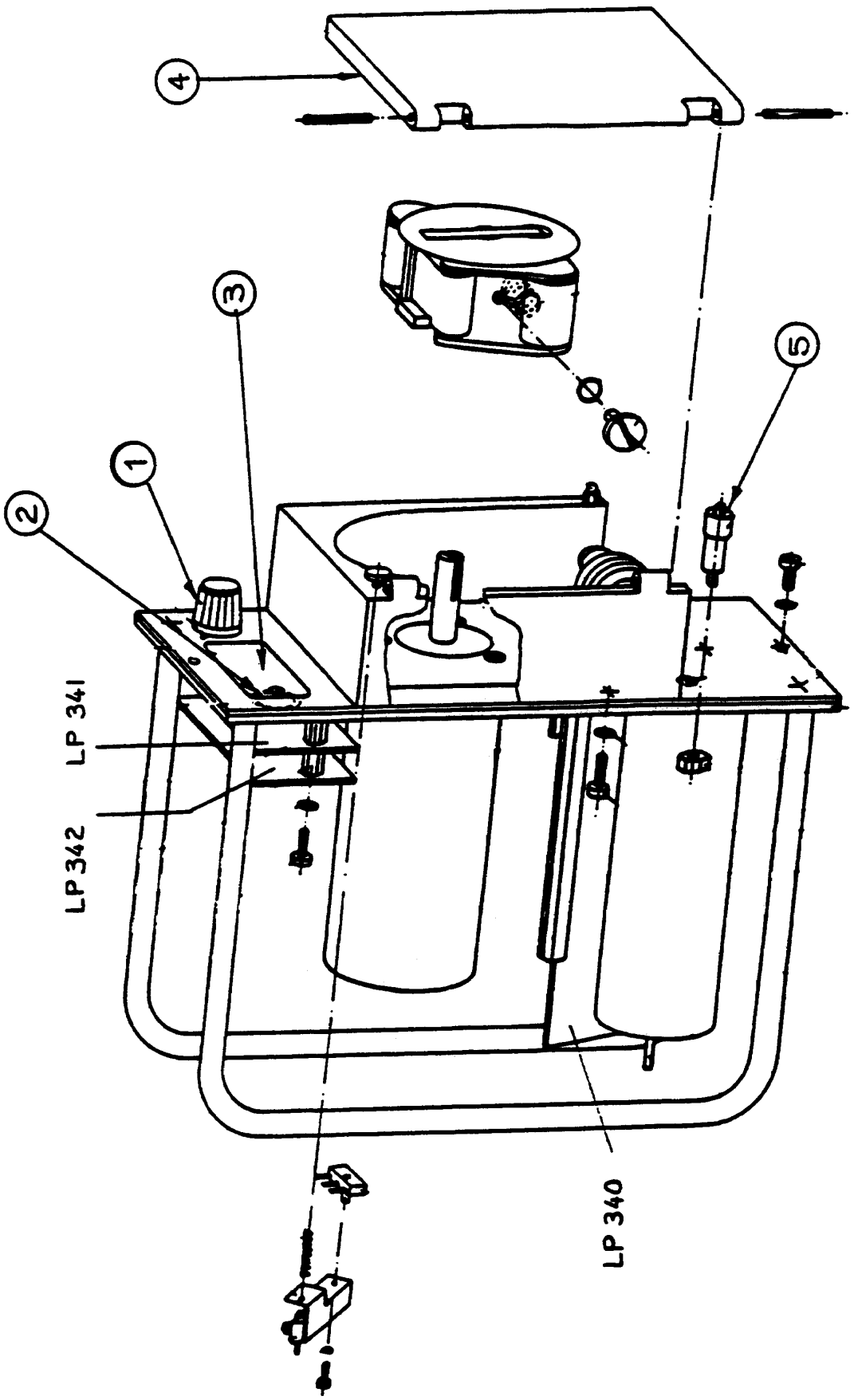
Item 3: Delivery rate display:
3 digit LED display Resolution: 10 ml
Stoppage alarm display-lights up if the rotor stops for 15 seconds (optional 30 seconds) when blood pump is switched on.

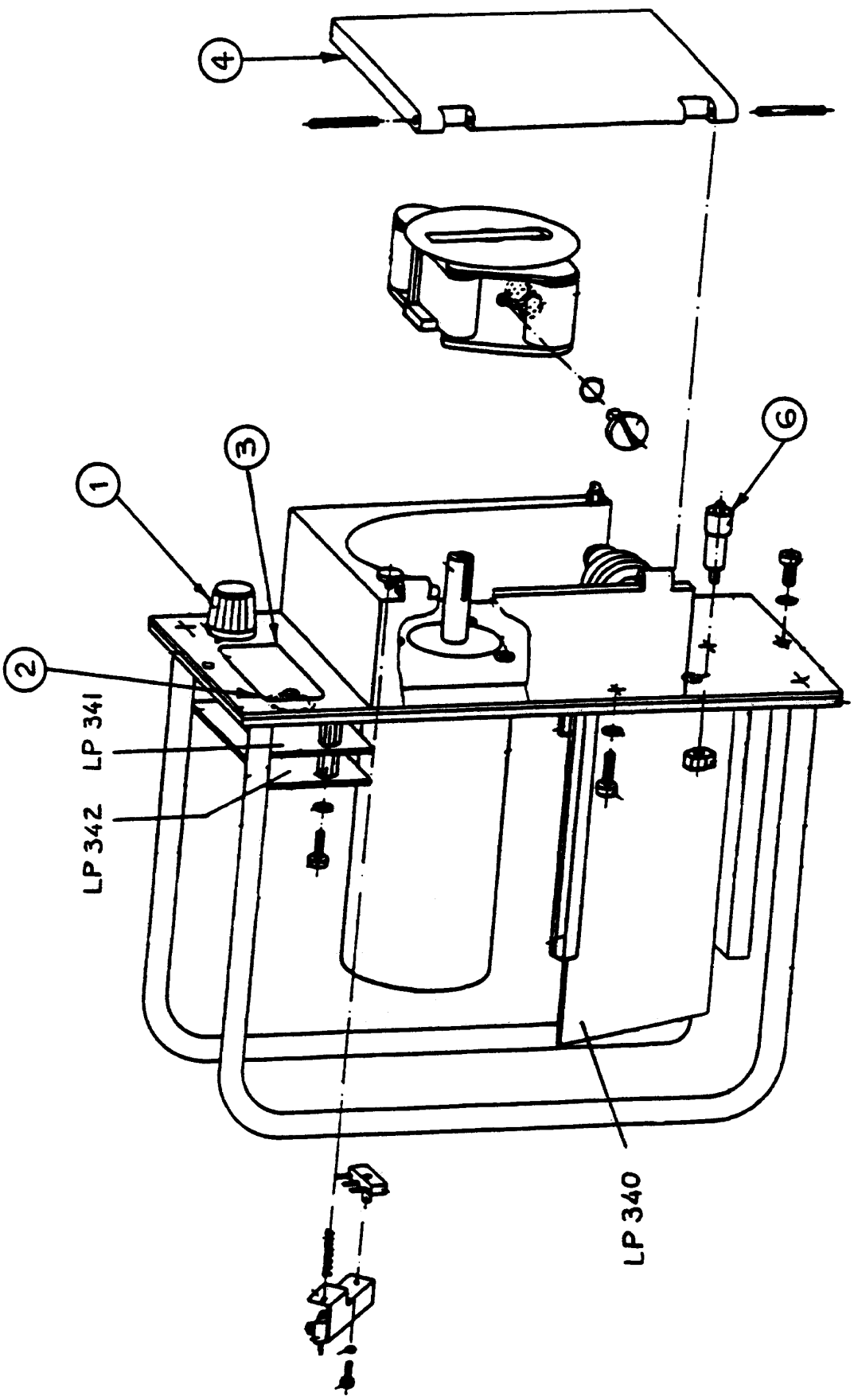
Item 4: Blood pump door.
Switches the BP off when opened.

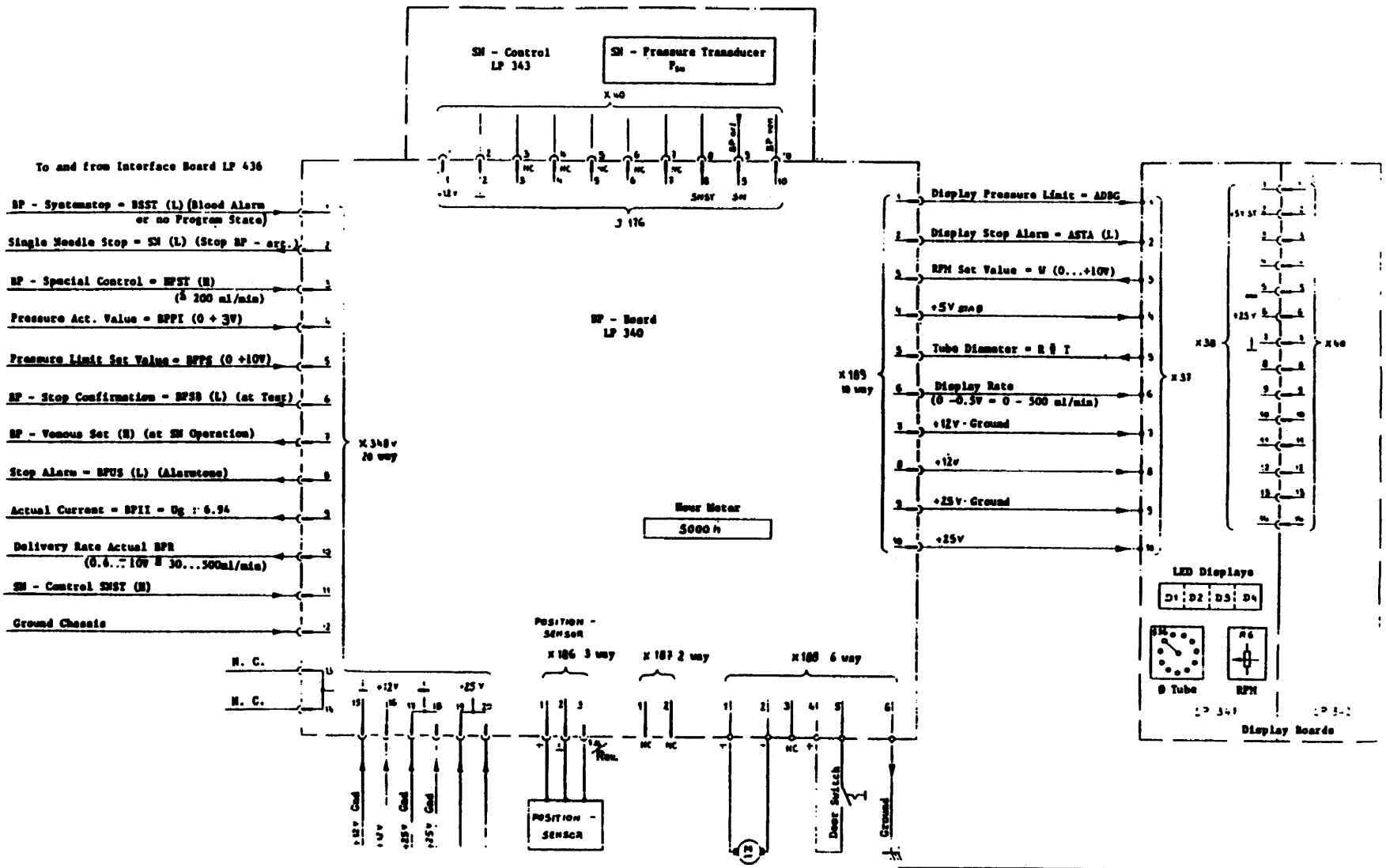
Item 5: single needle control pressure connection “P SN”. Luer-lock connection to take the SN control pressure line.

Item 6: Art. pressure connection “P ART”
Luer lock.

SINGLE NEEDLE BLOOD PUMP MODULE




ARTERIAL BLOOD PUMP MODULE
4
1
3
6
2
LP 341
LP 342
LP 340


SN - Control
LP 343
SN - Pressure Transducer
P
X 40
J 176
To and from Interface Board LP 436
BP - Systemstop = BSST (L) (Blood Alarm or no Program State)
Single Needle Stop = SN (L) (Stop BP - arg.)
BP - Special Control = BPST (H) (≙ 200 ml/min)
Pressure Act. Value = BPPI (0 ÷ 3V)
Pressure Limit Set Value = BPPS (0 +10V)
BP - Stop Confirmation = BPSB (L) (at Test)
BP - Venous Set (H) (at SN Operation)
Stop Alarm = BPUS (L) (Alarmtone)
Actual Current = BPII = Ug : 6.94
Delivery Rate Actual BPR (0.6...10V ≙ 30...300ml/min)
SN - Control SNST (H)
Ground Chassis
X 348 v
20 way
BP - Board
LP 340
Hour Meter
5000 h
N. C.
N. C.
+12V
+5V
+25V
Gnd
POSITION - SENSOR
X 186 3 way
X 187 2 way
X 188 6 way
Door Switch
Ground
Display Pressure Limit = ADBG
Display Stop Alarm = ASTA (L)
RPM Set Value = U (0...+10V)
+5V stab
Tube Diameter = ⌀ T
Display Rate (0 -0.5V = 0 - 500 ml/min)
+12V - Ground
+12V
+25V - Ground
+25V
X 189
10 way
X 37
X 38
X 40
LED Displays
D1 D2 D3 D4
R5
R6
⌀ Tube
RPM
Display Boards
VENOUS BLOOD PUMP
COMPLETE
650 222
FRESENIUS

The plug-in module contains operating and display elements together with the syringe holder.

Operating elements

Potentiometer: Calibrated setting of the delivery rate.

ON/OFF button: Illuminated.

Display elements

Alarm lamp: Lights up automatically if pump stops.

Heparin Pump

Item 1:	ON/OFF Switch Pump alarm is canceled by switching off and on.	ON/OFF Lamp Lights up when infusion pump is switched on.
Item 2:		Alarm lamp Lights up when there is a fault in the infusion pump.
Item 3:	Delivery rate selector with setting range from 0.5ml/h to 10ml/h	Delivery rate scale Resolution 0.2ml/h
Item 4:	Injection carriage w. locking button. THE RED RING ON THE CARRIAGE MUST BE VISIBLE. TIGHTEN LOCKING BUTTON.	

The heparin pump is designed for disposable 30 ml syringes.

Delivery rate: 0.5 to 10 ml/h, resolution: 0.2 ml/h

Delivery accuracy: ± 3% at 1 to 10 ml/h
±10% at 0.5 to 1 ml/h

The protective system for the pump comprises a speed monitor and a motor current monitor. If the speed deviates from its rated value by ±40% of the set value or if the motor current increases as a result of to high a delivery pressure or coming up against an stop, an alarm is triggered. The alarm lamp in the plug-in module and the MUTE led in the monitor light up and the audible alarm sounds.

The alarm is canceled by switching the syringe pump off. The syringe pump alarm is also canceled by the “RESET” keypad.

Circuit Description

The circuit can be divided into the following functional groups:

1. Voltage matching
2. Processing the alarm reset signal
3. Reference voltage with generation of the operating voltage Ub, alarm test input and voltage monitoring of Ub.
4. Generator voltage control with set-point adjuster.
5. Monitoring circuit for generator voltage with alarm output.

Voltage matching

The plug-in module is supplied with voltage (connector X350 + pin 13, 14 and pin 11, 12).

The voltage regulator U6 regulates the voltage for the motor and the circuit which generates the operating voltage Vm at 9.2 V ± 5.6% max. The resistors, R90 and R91 set the output voltage. The capacitors C37 and C38 are used to prevent any possible tendency of the voltage regulator to oscillate.

Processing the alarm reset signal

The alarm reset signal (connector X350, Pin 1) passes via C14, in the form of a negative pulse, through C41, to trigger timer, U5. This timer, is wired as a monostable toggle stage. The time constant is set by C39 and R88. The high time of the monostable toggle stage is approx. 500 ms following a trigger pulse. This part of the circuit is needed for switching on again following the alarm test, since the alarm might otherwise not be canceled. The capacitor C40 is used to stabilize the internal voltage divider of the timer. D25, R89 are used to limit the voltage of the timer trigger input.

Generating the operating voltage Vm

Since the timer, U5 only delivers a short, positive output pulse following a reset signal, the transistor Q13 is only inhibited for the duration of this pulse and is otherwise always biased into conduction. The voltage at the collector of Q13 generates the reference voltage of Q17 (2.45V ±2%) via the resistor R85.

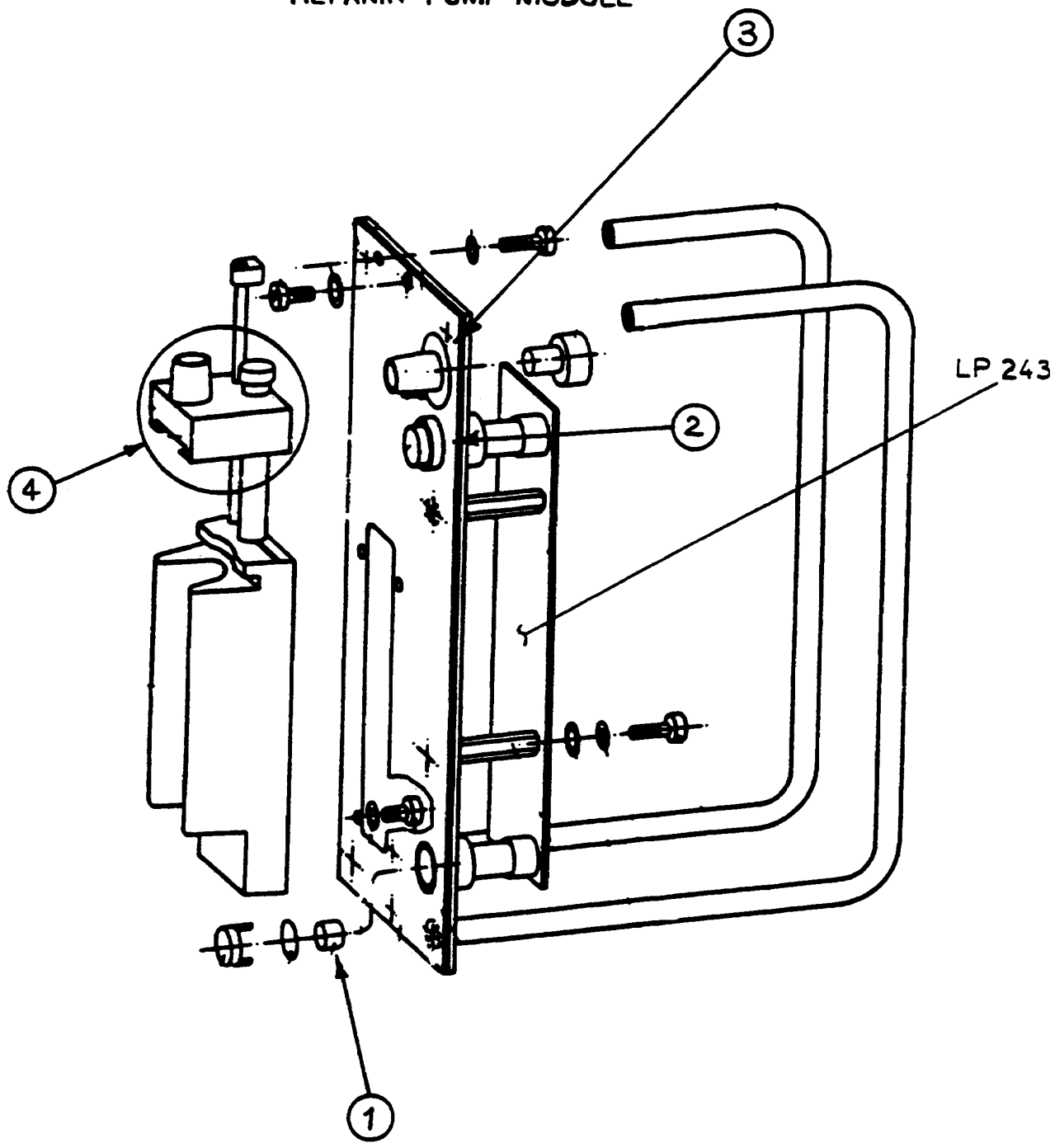
The Op. Amp. U4a with following transistor Q11 is wired as a voltage regulator.

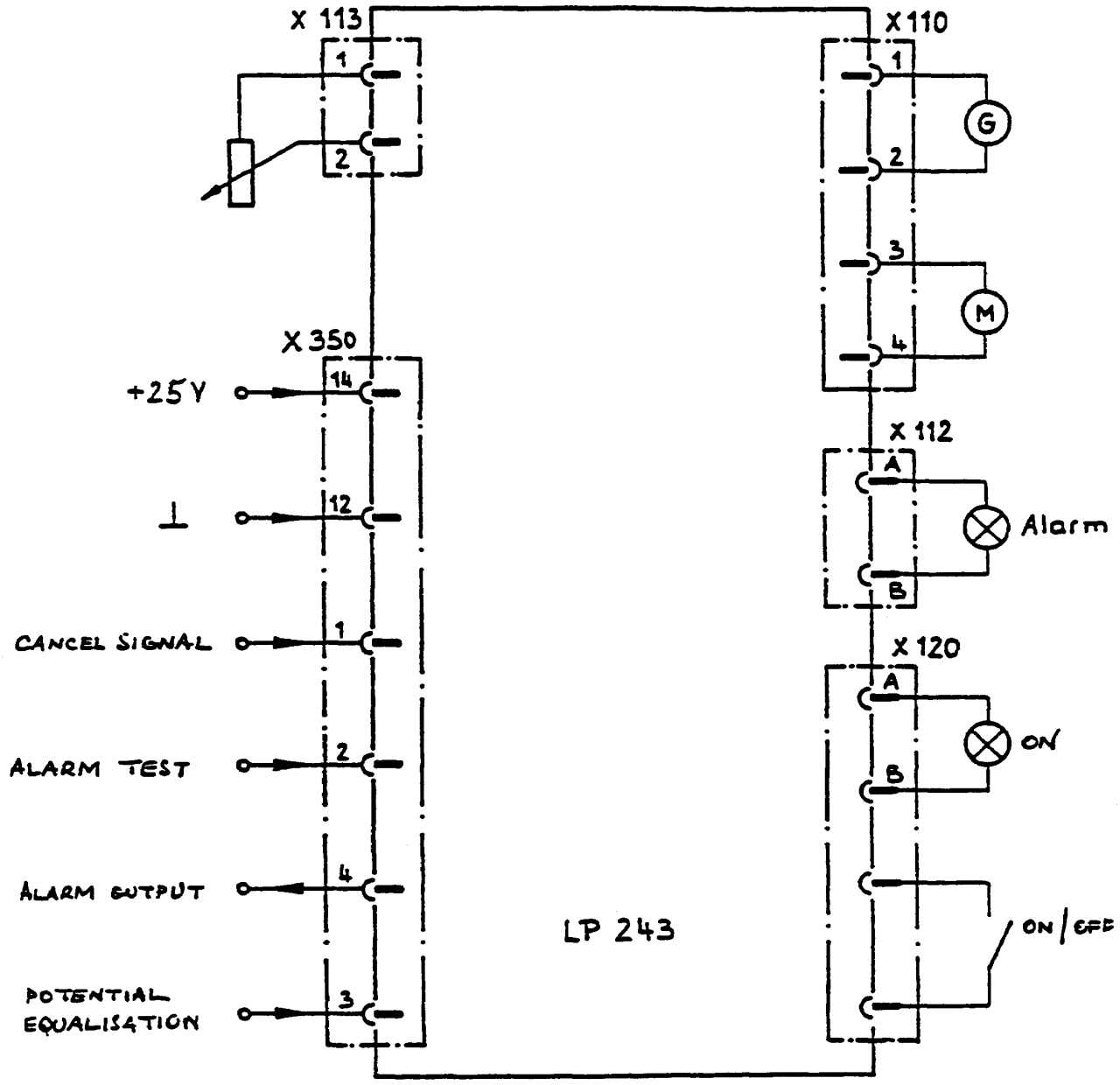
The size of the output voltage Ub at the emitter of Q11 (MP3) is determined by the resistors R78 and R79. It is 5V (±3%). This voltage supplies the set value for control and for monitoring.

During the alarm test an H-level is applied to connector X350 pin 2, whereby the resistors R76 and R77 are connected in parallel to R79 via the open collector stage Q92, 93, 12 and the voltage Ub (MP3) is raised to 6V (±3%).

The Zener diode D15 acts as a protection against excessive voltages of Ub in the event of a fault.

HEPARIN PUMP MODULE





			Fremdtoleranzen nach DIN 7168			Werkstoff	HEPARIN PUMP LP 243
			84	Tag	Name	PLUG-IN MODULE SP	
			Bearb.	14.2.	Ru.		
			Gepr.			30 ml	50 ml
			Norm.				
O.Ä.M.	11.7.84	Ru.				566 009	566 096
Änderung	Tag	Name					

AIR/FOAM DETECTOR / VENOUS CLAMP PLUG-IN MODULE

The plug-in module contains the holder for the venous drip chamber with air sensor, the connection for the venous return pressure and the venous clamp with optical blood/saline detector.

The venous drip chamber is pressed into the holder by the cover and is thereby slightly deformed. This is the only way to ensure proper function.

WARNING: The electronic adjustment procedure (see section “Calibration and Installation Procedures” for details) has to be performed for each drip chamber make and model. Make sure the filter in the drip chamber is below the sensor heads during the entire calibration procedure.

The venous drip chamber is connected via a filter to the pressure connection. The venous return pressure is indicated in the monitor.

The vent valve is located in the pressure line inside the plug-in module. The vent valve is controlled by the override automatic priming logic.

The venous clamp blocks off the extracorporeal circulation from the patient in the event of an alarm. The optical detector in the clamp holder detects blood in the tube system. Provided saline solution or air are present in the tube, the audible alarm, venous return pressure alarm and staff call are suppressed.

Functional description

The system that protects against air infusion, operates on a ultrasonic transmission principle. Ultrasonic transducers are fitted on both sides of the venous drip chamber. A transmitter oscillator generates exponential decaying ultrasonic bursts with a natural resonance frequency of 90 kHz and a repetitive period of 90 ms. This signal is picked up by the receiving transducer. The amplitude of the signal received depends on the medium. When the drip chamber is empty (air), the receiver output is minimal. In the case of bubble-free liquids it is at its maximum. As the air content increases (foam) the amplitude drops.

WARNING: The electronic adjustment for the system consisting of transmitter, drip chamber, receiver is only valid for one particular drip chamber make or model. Each change in drip chamber make or model requires a new adjustment!

The transmitter and receiver transducer are fail-safe always causing an alarm if they fail. From the receiver transducer on the signal voltage is passed through two independent paths. If the signal is too weak one path will trigger the blood pump stop while the other will close the venous clamp.

Optical Detector

The purpose of the optical detector is to differentiate between blood and saline solution or air in the venous return bloodline below the drip chamber. In the 2008H, the dialysis phase is defined by the presence of dark medium and the dialysate tube off the shunt. The preparation phase is defined by the presence of a light medium.

Venous pressure measurement

The venous pressure gauge consists of a piezo-resistive pressure and amplifier sensor. The pressure-proportional output voltage is transmitted to the PCB in the monitor. Here the pressure is displayed by the display board and the pressure is calculated by determining the difference between the dialysis fluid pressure and the venous pressure.

$$TMP = Pv - Pd$$

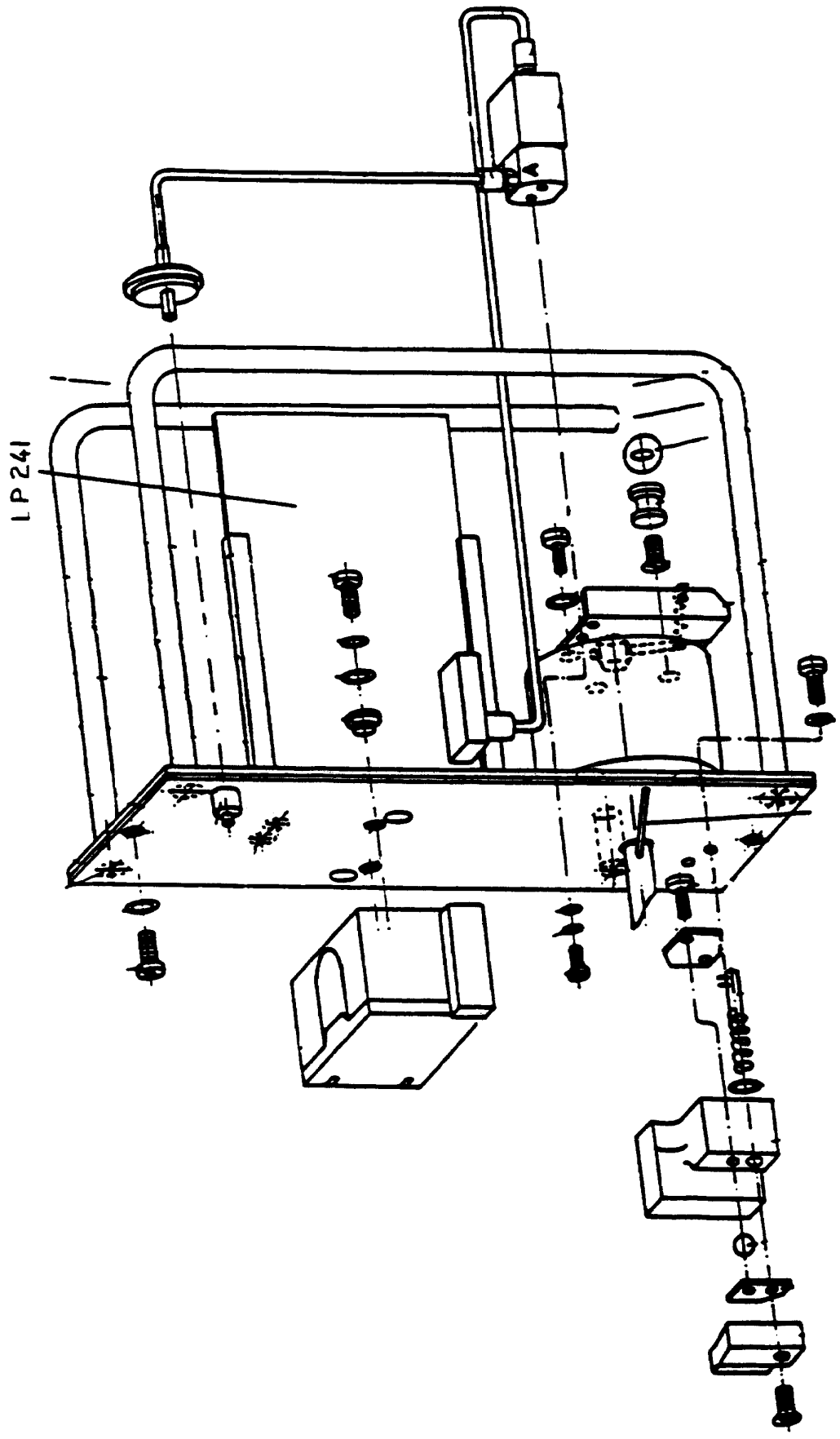
Circuit Description

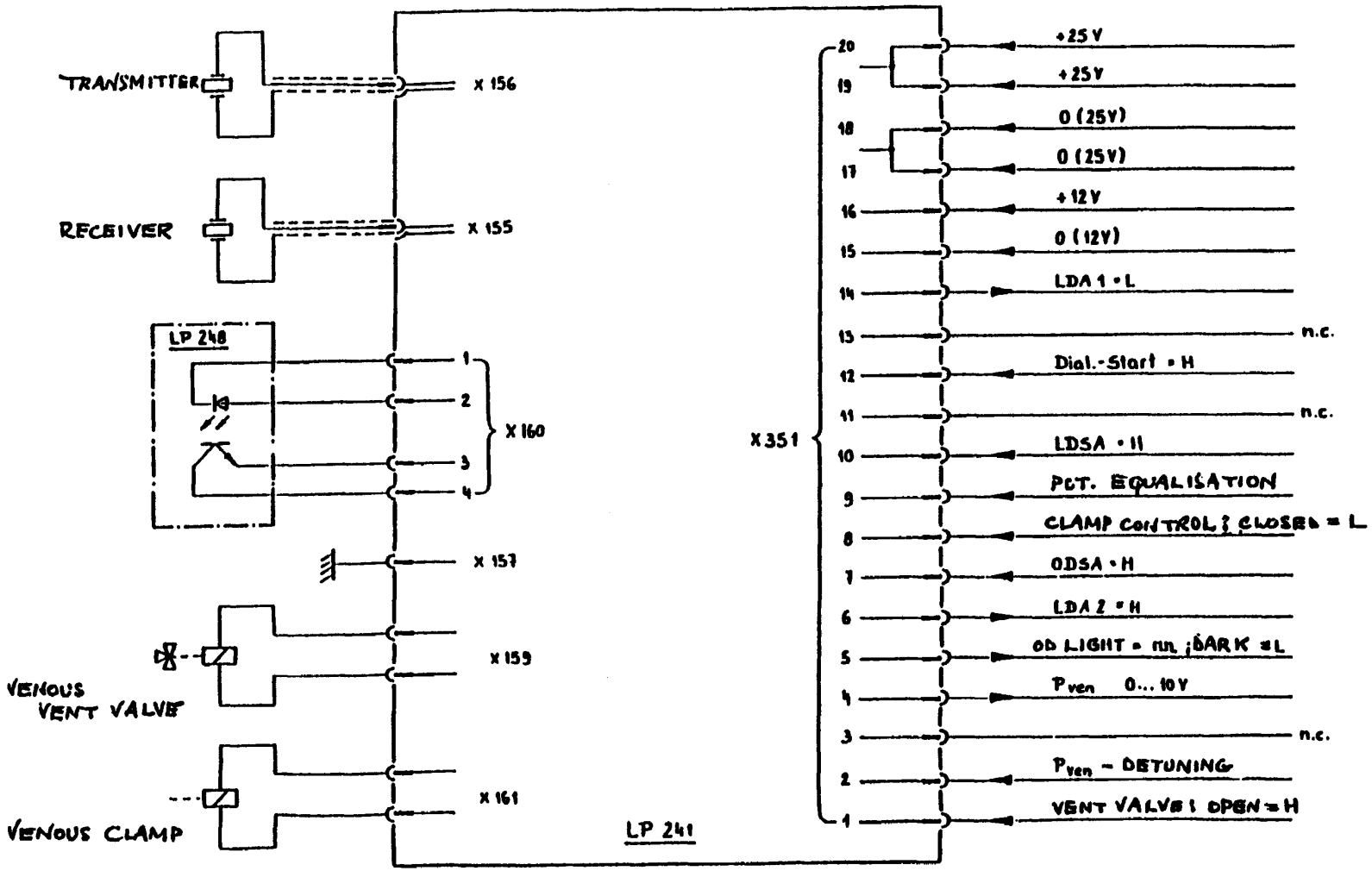
Air Detection: (Acoustic Section)

Transmitter: The self capacitance of the transmitting transducer is charged via R114 to + 12V and periodically discharged via Q20. The discharge current stimulates the oscillator to produce an ultrasonic oscillation. If the jumper J164 is plugged in, then the transducer is only charged to +6V as a result of the voltage division between R114 and R113. This reduces the amplitude by half. If the transistor Q21 is energized, then the transmission amplitude is reduced to a third as a result of the voltage division of R114 and R11 for test purposes.

Receiver: Up to the outputs of the alarm one shots U3 and U6, both receiver channels are identical. Therefore this description is limited to the upper channel. The voltage delivered by the receiver transducer is amplified by Q15 and transmitted to op amp U1 which functions a precision rectifier. At the cathode of D32, an amplified, positive half-wave appear (which drives comparator U2b through R-C network R80 and C50). If the peaks of the signal exceed the reference voltage at pin 6, the output 7 produces positive pulses at 90ms intervals which, having been inverted by Q16, are found at the trigger input pin 5 of the first one shot U3a. Both the one shots of U3 are of the retriggerable type. The first has a time constant of 60ms and the second of 480ms. The first time constant of 60ms was chosen, so that following each trigger pulse on the input side, the output can switch back by the time the next trigger pulse arrives. If this is the case, then the second one shot is retriggered at 90ms intervals and its output pin 10 remains high (alarm-free). If, as a result of too small an input signal, the comparator does not trigger the one shot, the second one shot switches back after 480ms and transmits a low to pin 14 of connector X351. This low then sets an alarm memory on the alarm processing board, LP424, which stops the blood pump. With the exception of the longer, 700ms time constant of the second one shot U6b, the second receiver channel operates in the same way. However, in the event of an alarm, the output pin 9 sets the memory flip-flop U7b with a high. The latter's output pin 12 then inhibits FET Q27 and cut off a 25V level is applied at pin 6 of connector X351 via R124. This voltage is interrogated during the alarm test, in order to establish whether the venous clamp was switched off by the second receiver channel. If, in the meantime the alarm state has been removed, the flip-flop U7b is reset by the positive edge of the dialysis start pulse of pin 12 of the connector X351. In this case a high at pin 12 of U7b reconnects the FET Q27 and the venous clamp is opened.

AIR/FOAM DETECTOR





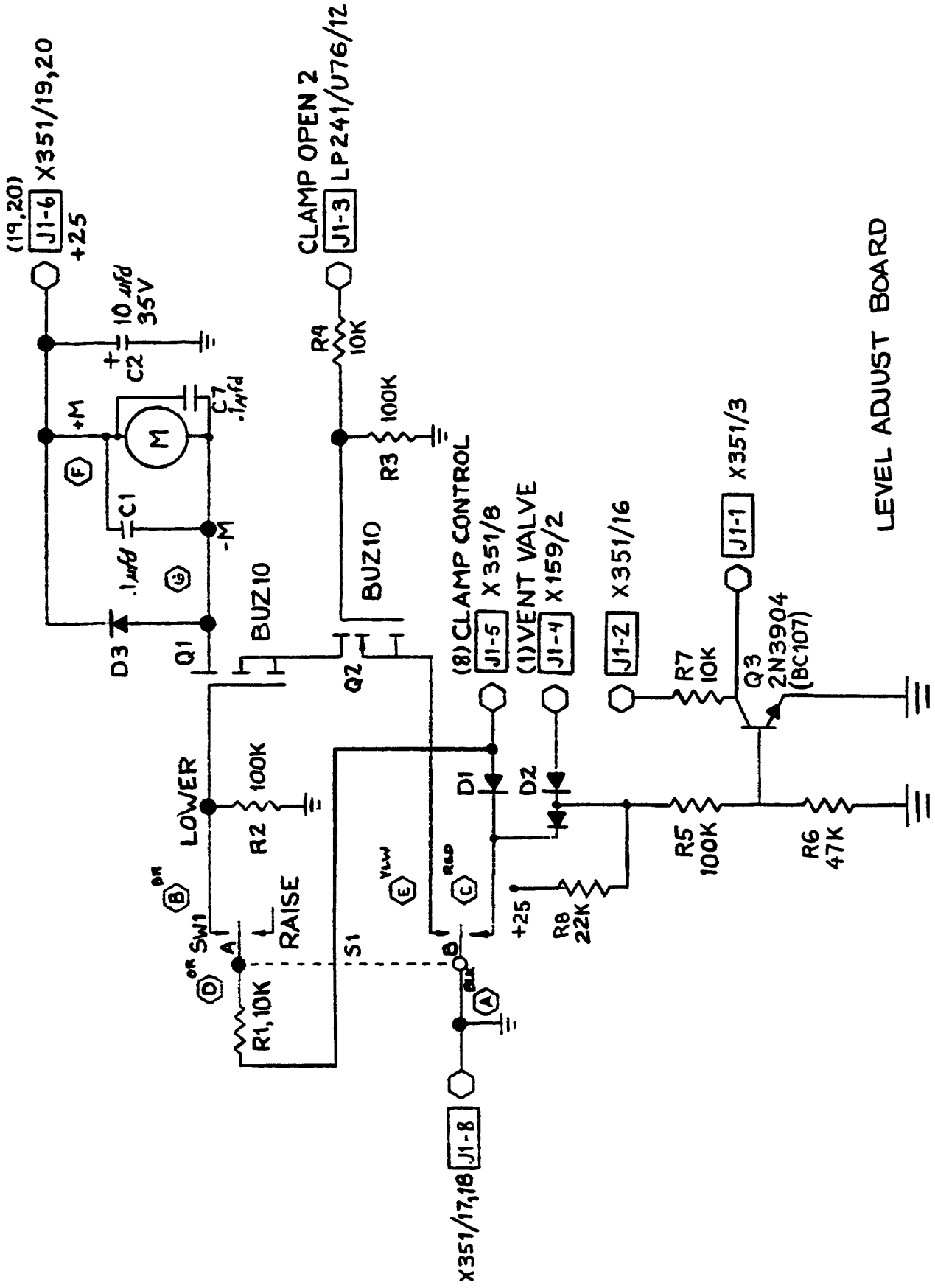
						Werkstoff	AIR/FOAM DETECTOR
				Bl.	Tag	Name	
				Bearb.	12.8.	Thu.	Signalplan LP 241
				Kontr.			
				Norm.			
				FRESENIUS MEDIZINTECHNIK			650 414
Ausgabe	Änderung	Tag	Name				

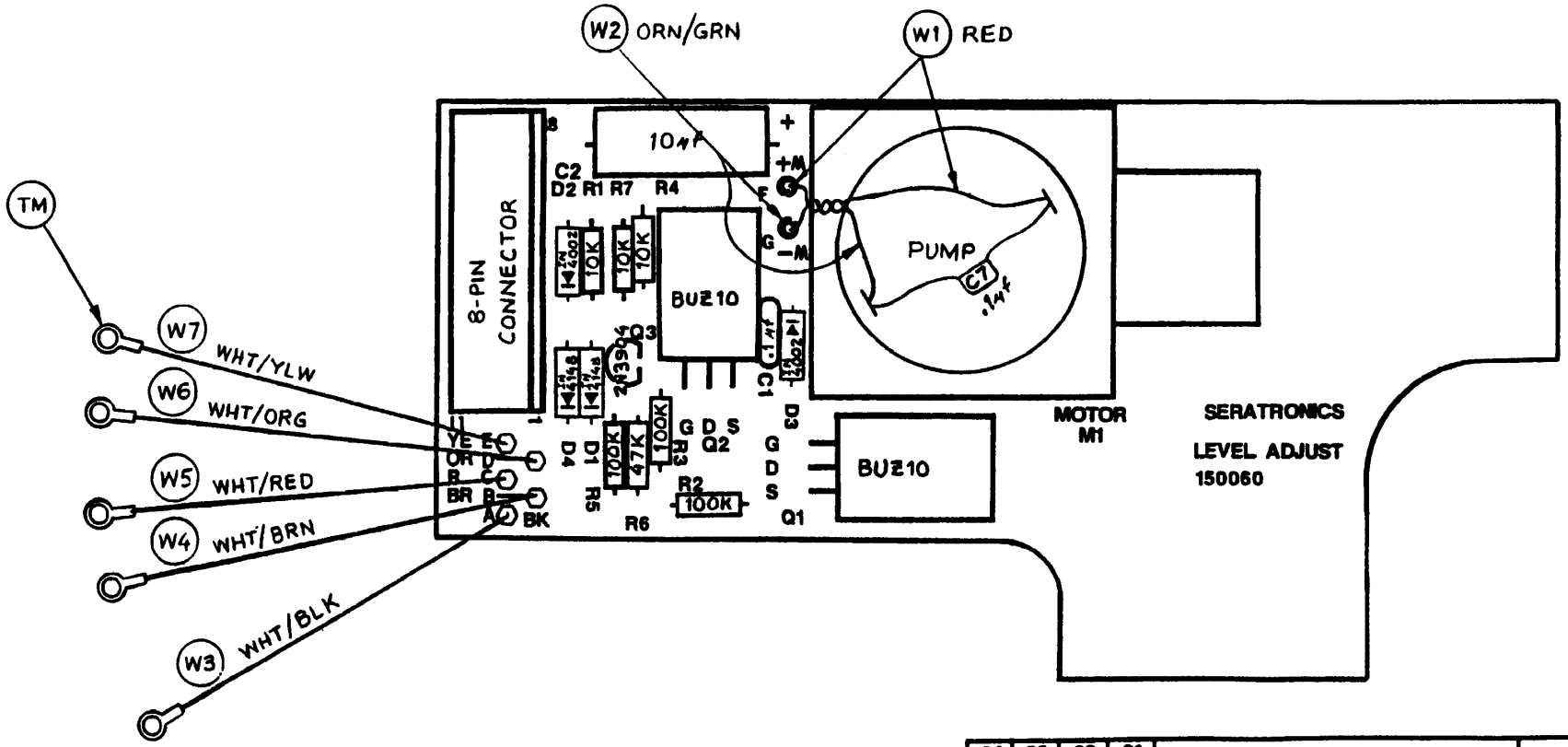
Maßstab	%
	VP

Level Adjust Board

Pushing the toggle switch upward closes with low level on J1-5 the venous clamp on the air/foam detector and low level on J1-4 opens the vent valve. Also transistor Q3 turns off and slows down the speed of the blood pump to 150 ml/min max. with a high level on J1-1.

Lowering the level in the drip chamber is only enabled if there is no air/foam detector alarm present. That is when J1-3 and J1-5 are high. Pushing the toggle switch downward supplies the high level from J1-5 to the gate of Q1 and low level to the source of Q2. This will turn on transistors Q1 and Q2 turning on the pump. This pumps air into the drip chamber and causes the level to drop.


LEVEL ADJUST BOARD
(19,20) J1-6 X351/19,20
+25
10 mfd 35V
C2
+M
C7 .1mfd
M
C1
.1mfd
-M
D3
Q1
BUZ10
CLAMP OPEN 2
J1-3 LP241/U76/12
R4 10K
R3 100K
BUZ10
Q2
(8) CLAMP CONTROL
J1-5 X351/8
(1) VENT VALVE
J1-4 X159/2
J1-2 X351/16
J1-1 X351/3
R7 10K
Q3 2N3904 (BC107)
D1
D2
LOWER
R2 100K
RAISE
SW1
S1
R1, 10K
+25
R8 22K
R5 100K
R6 47K
X351/17,18 J1-8



-04	-03	-02	-01	DESCRIPTION	PART NO
QUANTITY					

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TOLERANCES UNLESS NOTED

XXX (3 PLACES DEC.)	+.005-.005
XX (2 PLACES DEC.)	+.01 -.01
FRACTIONS	+1/32-1/32
ANGLES	+1/2°-1/2°

DO NOT SCALE THIS DRAWING

DWN: DS	DATE: 1-14-88	
CHK:	DATE:	
APPR:	DATE:	SCALE:

TITLE: LEVEL ADJUST ASSEMBLY

SHEET 1 OF 1 | DWG NO. 150060

BLOOD PRESSURE MODULE BPS08

THEORY OF OPERATION
1. General

The oscillometric method is currently the most advanced and most error free method of obtaining non-invasive blood pressure measurements available today. The placement of the cuff on the arm is not critical, although the "target" on the cuff should be in the vicinity of the brachial artery. The ambient "noise" is not a factor and the rapid inflation and deflation of the cuff during a reading "cycle" are generally unobtrusive. The anatomy of a measurement cycle begins when the cuff is inflated to at least 30 mmHg over the actual systolic point, which in the case of the BPM, is determined from the previous reading. As the brachial artery is occluded, the lower arm is drained of blood by way of the venous system, and the systolic pressure pulses "throbbing" at the occluded artery cause low amplitude pressure propagation waves which are transmitted from the cuff via the connecting tubing to the pressure transducer in the module. This ambient pressure oscillation is processed by the system algorithm and is interpreted as the "base line". The computer system continues to process the incoming pressure pulses looking for a large amplitude signal that will indicate the first systole pulse that goes through the now only partially occluded brachial artery and is identified as the systolic blood pressure. The blood pressure module continues to monitor the incoming pressure pulses while at the same time counting their frequency against an internal clock which accomplishes two tasks: (1) any signal received that is not within the time window established by the pulse frequency vs. the internal clock is interpreted as not of physiological origin and discarded, and (2) the pulses accumulating while the clock is running are counted, processed by the computer, and displayed as heart rate or "pulse". The pulse propagation waves continue to be received and interpreted by the Blood Pressure Module until a very low amplitude signal is received that disappears quickly and immediately after that, the algorithm calculates the time when the next pressure pulse would occur, and uses the point between the two (between Swann points 4 and 5) to determine the diastolic point.

Mean arterial pressure (MAP) is determined by the most frequently used formula:

$$MAP = [(systolic - diastolic)/3 + diastolic]$$

which will correlate with most of the MAP data currently available.

- Plug-in module for Fresenius Hemodialysis Machine
- Oscillometric for greater accuracy
- Fully Automated
- Non-invasive
- Objective
- Artifact recognition and rejection
- Visual/Audible alarm system
- Selection of Blood Pressure determination frequency
- STAT button
- Auto zeroing of pressure transducer
- Digital display
- Standardized MAP algorithm for system correlation with other MAP data
- Continuous Mode available for emergency situations
- Accurate in measuring hypotensive patients
- State of the art pressure transducer provides accurate determinations for neonates, pediatric and geriatrics

2. Reading determination sequence

1. Occlusion of the brachial artery
2. Low level oscillations of the brachial artery (Baseline)
3. Determination of systolic blood pressure Pulsation/elapsed time
4.* Determination of diastolic blood pressure
5.* Determination of pulse (heart) rate
6.* Determination of MAP (Mean Arterial Pressure)

* Simultaneous for all practical purposes.

PHYSICAL DESCRIPTION

General description of characteristics and safeguards

Technique
Measures systolic, diastolic pressures, and heart rate (pulse rate) using the oscillometric method. MAP calculated from systolic and diastolic values.

Cuff Deflation
Interactive computer controlled. Determination in adult mode requires approximately 25 to 30 seconds depending on starting point, heart rate, and motion artifact.

Cuff Inflation
Typically 5 seconds from 0 to 250 mmHg.

Digital display
16 positions, 0.5 inches high displaying data in "billboard" fashion for maximum information available and ease of reading. Format is:

No motion artifact	Sys000MAP000Dia000Puls000
With motion artifact	MoASys000MAP000Dia000Puls000

In addition to the motion artifact which is indicated in conjunction with blood pressure and heart rate data, there are eleven error indications that appear without readings:

1. ZoP; Zero Pressure
2. POT=30; Pump-on timer on for 30 seconds (adult), 10 seconds (neonate)
3. CPU<10; Cuff pressure is under 10 mmHg (adult), 5 mmHg (neonate)
4. ND15; No deflation for 15 seconds
5. IIP; Insufficient Inflation pressure
6. OWC; Oscillation Wave check
7. PAU; Pulse Amplitude Uniformity
8. M>90; Measurement for 90 seconds
9. >100P; 100 pulses or over during a measurement
10. CPO>325; Cuff pressure is over 325 mmHg (adult), 220 mmHg (neonate)
11. WeP; Weak pulsations

Clock
Display shows elapsed time to next blood pressure test.

Automatic Measurement Cycles
Selectable cycles are 15, 30, 45, and 60 minutes.

STAT Button
The stat button immediately initiates one test whether in the timed mode or the stand-by mode and does not affect the elapsed time to the next test.

Confirm button
The display will hold the reading until the confirm button is activated thus indicating to the BPM that the data is recorded. If 20% of the set time has elapsed without confirmation, a "clicking" will sound to remind the staff to record the data. If the data is not recorded when the next test takes place, the BPM discards the old data and displays the new reading.

Auto zeroing
Zero pressure compensation is an automatic function of the BPM.

Cuff deflate
The cuff deflate button will instantly terminate the blood pressure test and deflate the cuff in the event of an emergency.

Alarm Indication
In the event of an alarm, a buzzer will sound and the alarm light will go on. In the event that processing by the BPM is interrupted, a separate alarm will sound indicating that the BPM is no longer monitoring the patient.

Options Menu
A selectable "options menu" provides one additional operating mode, selection of a neonatal mode (if available in your BPM), and four self-test modes. See Section 4 operating instructions (4.2.1 and 4.2.2) or, Section 6. Calibration and performance verification for detailed information on these modes.

Serial Data Output
A printer and computer compatible serial output is available at the back of the BPM.

Self Check
An automatic self-check of the RAM and ROM in the BPM is performed when the power is turned on. The results are displayed only when there is an error signal present.

Neonatal Capability
On a special order basis, the Fresenius Model BPS08 Blood Pressure module is available with the capability of accommodating neonates. The operating characteristics are exactly the same with the exception that the performance specifications and minimum and maximum measurement capabilities are changed. In addition, the inflation increments and the error code parameters are reduced to match the performance specifications. THE ONE MAJOR DIFFERENCE IS THAT PRESET ALARM PARAMETERS ARE NOT AVAILABLE IN THE NEONATAL MODE. For information on the availability of BPM's with neonatal capability contact Fresenius or your sales representative.

TABLE I
PERFORMANCE SPECIFICATIONS

Specifications	Performance Limits	
	Neonatal	Adult/Pediatric
Cuff Pressure Range (Display Range):	10-325 mmHg	5-220 mmHg
Initial Cuff Inflation:	120 mmHg or adjusted by Host	180 mmHg or adjusted by Host
Systolic Determination Range:	40-160 mmHg	60-260 mmHg
MAP Determination Range:	25-135 mmHg	35-220 mmHg
Diastolic Determination Range:	15-120 mmHg	25-200 mmHg
Pulse Rate Determination Range:	40-240 bpm	40-180 bpm
Pulse Rate Accuracy:	± 5% of Reading	± 5% of Reading
Inflation time:	Within 3 seconds 0-200 mmHg	Approx. 5 seconds from 0 to 250 mmHg
Determination Time		
Normal Mode:	Approx. 20 seconds	25 to 30 seconds
Quick Systolic Mode:	Not Applicable	Approx. 12 seconds
Over pressure Cut Off:	220 mmHg	325 mmHg
Transducer Drift:	Auto Zeroing	Auto Zeroing
Leakage Rate (Max.):	3 mmHg/3 minutes	3 mmHg/3 minutes
Pressure Rate Offset:	Auto Zeroing	Auto Zeroing
Pressure Accuracy Overall:	± 5 mmHg ±8 mmHg SD	
Pressure Transducer Accuracy:	± 3 mmHg or ±2% of Reading	

TABLE I
PERFORMANCE SPECIFICATIONS
(continued)

Specifications	Performance Limits				
	Neonatal		Adult/Pediatric		
Alarm Preset Values:* (Internal Alarm values to protect the patient in the event individual values are not entered)	None		Systolic	165	90
			MAP	120	70
			Diastolic	100	60
			Pulse	180	40
Alarm Parameters: Settable in increments of 5mmHg	Systolic	40-160 mmHg		60-150 mmHg	
				80-260 mmHg	
	MAP	25-140 mmHg		40-150 mmHg	
				80-240 mmHg	
	Diastolic	15-120 mmHg		25-150 mmHg	
				80-200 mmHg	
	Pulse	40-240 Bpm		40-140 Bpm	
				80-180 Bpm	

* The preset alarm values used represent the 95th percentile or above for a population of adults 18-74 years of age and were taken from the following study: Blood Pressure Level in Persons 18-74 Years of Age in 1976-1980: and Trends in Blood Pressure from 1960-80 in the United States. Vital Health Statistics Series 11, No. 234, Washington, D.C., U.S. Dept. of HHS, National Center for Health Statistics, Publication No. (PHS) 86-1984, 1986.

TABLE II
GENERAL SPECIFICATIONS

Resolution	Blood Pressure = 1 mmHg Heart Rate = 1 Beat per minute
Power Requirements:	+5V 0.4A +12 V 0.3 A -12 V 0.1 A
Pump Voltage:	+12 V 1.3 A (max.) 0.6 A (steady)
Power Consumption:	6.8 Watts
Leakage Current:	Less than 100 microamps
Ambient Temperature:	10°C to 40°C Operating
Storage Temperature:	-20°C to +50°C
Relative Humidity:	5 to 95% (non-condensing)
Altitude:	-500 to +5,000 feet
Dimensions:	Width: 4.75 inches Depth: 7.50 inches Height: 11.00 inches
Weight:	approx. 5 lbs.

BLOOD PRESSURE MONITOR TEST SEQUENCE

1. Turn selector switch to the set parameter position. This is the normal mode to select and set the alarm parameters.
2. In order to select the test/calibration check mode, press and hold in the “set” button. While holding the “set” button, also press and hold in the “lower” (“—“) button.
3. Display will show inflation time.
4. If you wish to perform this procedure, attach a 200 ml volume to the cuff hose and press “raise” (“+“). If you do not wish to perform this test, press “set” to step through the tests. The tests are in the following order:
    a. Inflation time
    b. Deflation time
    c. Air leakage rate
    d. Pressure calibration
5. When the desired test is displayed, press “raise” (“+“) to initiate the test. At the completion of each test, the next test will be displayed.
6. At the end of the “pressure cal” test, a test of the mechanical overpressure sensor can be performed as follows:

    When the BPSOB is in the pressure calibration mode, all of the software is “locked out” (non functional) so this mode can be used to check the function of the mechanical overpressure sensor while the software overpressure sensor cannot intervene. Attach a hand held inflation bulb and vigorously squeeze the bulb until a pressure over 300 mmHg is reached.

    At this point, the mechanical overpressure sensor should open and vent the pressure to zero. The reset button will restore the sensor to its normally closed position.

    Pressing “cuff deflate” will return the operator to the alarm limit setting mode.
7. At any time throughout the test/cal procedure, you may press “cuff deflate” to terminate the test and return to the alarm limit setting mode.
8. Move the selector switch out of the “set parameter” position to return to normal operation.
9. All of the first 3 tests; inflation time, deflation rate and air leakage rate require a 200 ml shatterproof vessel as a substitution for the cuff.

10. When performing the fourth test, pressure calibration, a “Y” connector should be used to attach a pressure standard to the system.

11. Normal values for the tests are as follows:

    a. Inflation time = Between 0.8 seconds and 1.2 seconds

    b.

Deflation rate	Speed	Nominal
from 240 mmHg	4.6 - 6.2 mmHg/sec	5.3 mmHg/sec
from 160 mmHg	4.6 - 6.2 mmHg/sec	5.6 mmHg/sec
from 80 mmHg	3.2 - 5.2 mmHg/sec	4.1 mmHg/sec
from 40 mmHg	2.6 - 4.4 mmHg/sec	3.5 mmHg/sec

    c. Air leakage rate should not exceed 1.0 mmHg/min.

    d. Pressure calibration:

    Difference should not be more than $\pm$ 1.8 mmHg.

TROUBLESHOOTING GUIDE

Problem	Possible Cause
- No power to module. - Autocheck does not start. - No display.	(1) Is hemodialysis machine plugged in and the main switch on? (2) Check to see that the blue ribbon cable from the blood pressure module is plugged into the hemodialysis machine. (3) Check 20 pin connector to the internal central module. (4) Check connectors on the interface board.
- No cuff inflation.	(1) Check to see if the pump is running. (2) Be sure the tubing to the module port is securely fastened. (3) Be sure the tubing segment is firmly attached to the cuff. (4) Inspect the cuff for air leaks.
- No cuff deflation.	Software or hardware malfunction. Contact your Fresenius service representative.
- Incomplete Blood Pressure values. - Blood pressure values inconsistent with patients' history. - Are the blood pressure results clearly in error.	(1) Is cuff placement correct. (2) Is the cuff being used the right range. (3) Is the cuff placed over clothing (4) Is the clothing binding on the upper arm. (5) Is the patient accidentally compressing the cuff tubing.

If the problem persists after checking the recommended possible causes, contact your Fresenius service representative.

MAINTENANCE

The Fresenius Model BPS08 Blood Pressure Module requires minimum maintenance because of its rugged construction and long life components. The display is certified to function for a minimum of 40,000 hours MTBF and the air pump and motor are self-lubricating. The inflation system (cuff, bladder, and tubing) should be checked periodically for wear spots that may form pinhole leaks in the future. The male Velcro “hooks” should be cleaned of fibers, threads, and other extraneous “debris” that may affect their efficiency.

The Blood Pressure Module faceplate may be cleaned with diluted bleach or any common disinfectant used for other hemodialysis console components. Solvents containing high concentrations of alcohol such as methanol, ketones such as acetone, or chlorinated solvents should not be used as they may attack the plastic front panel parts. Solvents containing trichloroethylene are also not recommended.

The calibration of the pressure transducer should be checked at least every 500 hours of operating time.

The Inflation Time Test, Deflation Time Test, and Leak Test should be performed every 2000 hours at the same time as the routine maintenance for the hemodialysis machine.

S E C T I O N V I

CALIBRATION AND INSTALLATION PROCEDURES

INSTALLATION AND START UP

1. Connect water supply and main power. The machine is full of antifreeze if delivery was directly from the factory. Connect the drain line (do disconnect the overflow line). The antifreeze is frost proof down to approx. -20°C and consists of:

   28.0% by volume glycerol
   71.25% by volume water
   0.75% by volume formaldehyde

2. Rinse hemodialysis machine for 10 minutes without heating (automatic circuit breaker at "0") - then switch heater on again. Some flow out the overflow tube is normal here. Place the tube in a container during this first flush. If overflow does not stop, remove and clean float switch.

   Important: Test for residual disinfectant from shipping solution before use.

3. If the machine is empty, fill the hydraulics beforehand, to prevent the gear pump from running dry. Follow the procedure below:

   A. Switch off hemodialysis machine.
   B. Remove lower rear panel and distribution box cover.
   C. Pull out plug 20 from distribution PCB LP706 - deaeration pump not operating.
   D. Remove hose 1 from suction side of deaeration pump.
   E. Pull out float switch plug 5 from distribution PCB LP706.
   F. Override pin I and III at socket 5/LP706 (short circuit terminals) - this opens V41.
   G. Switch on hemodialysis machine.
   H. If bubble free water runs out of the overflow, block the latter.
   I. If bubble free water runs out of hose 1, close V41 and open overflow.
   J. Connect float switch 5 to socket 5.
   K. Replace connector 20 and the deaeration pump will immediately start aspirating water thus filling the remaining dialysis fluid circulation.

4. If no flow sets in, refill - otherwise check deaeration pump if necessary.

5. Measure the resistance from the machine ground lug to the ground connection at the wall. It must be $\leq$ 0.2 Ohms.

6. Enter the information into the machine for the acid and bicarbonate type desired by the facility.

7. If either concentrate is supplied to the machine with a pressurized central feed system, install the optional check valves for 6 psi (part# 332133-11) following the concentrate pumps as shown in the hydraulic flow diagrams.

   Important Note: Disinfect machine prior to use by a patient.

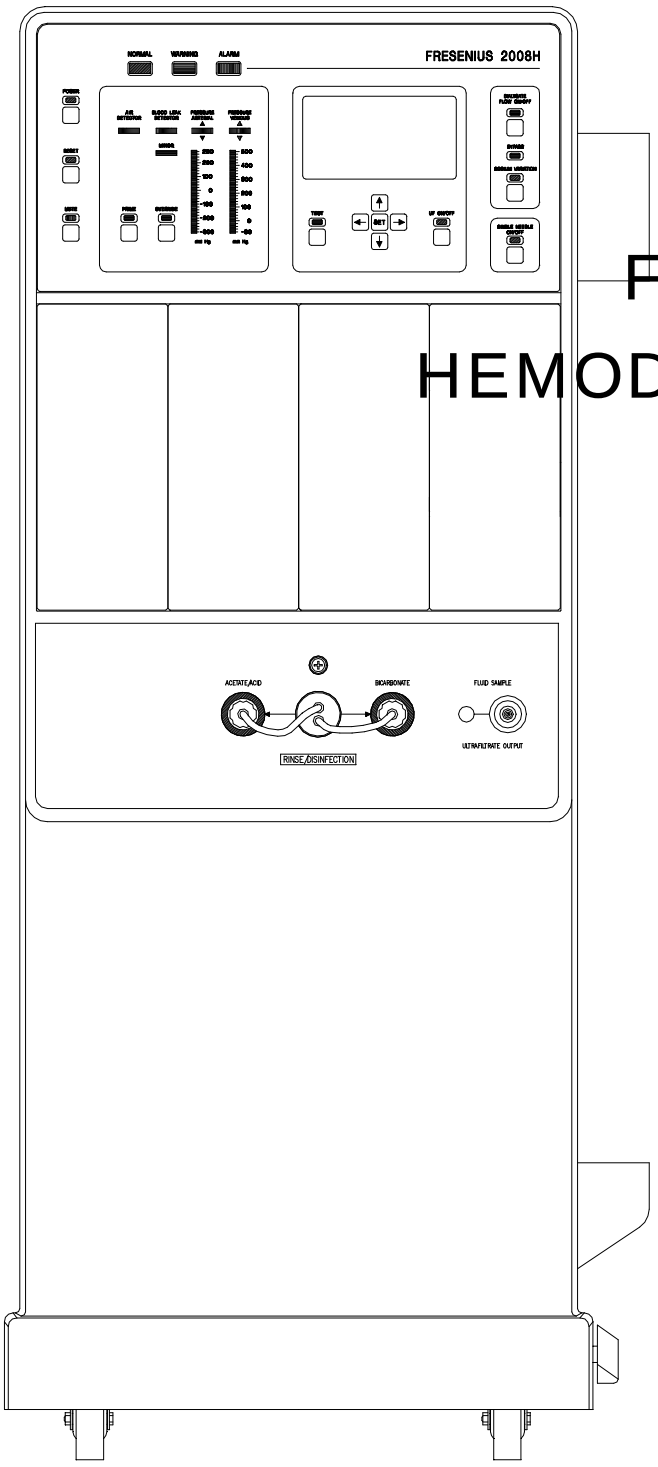
CALIBRATIONS

Calibrations are done in the Service Mode. To enter the Service Mode move the service switch to the up position. The switch is located on the rear of the electronics monitor, upper left side.

NOTE: The machine must be off while switching to service mode. If the switch position is changed with the machine powered up, there is a danger of losing all the calibration data.

Turn the machine on and the Calibration/Diagnostics Screen will be displayed. Using the up and down arrow keypads, select CALIBRATIONS and press the SET key and the Calibration Menu will be displayed. You may select the calibration desired by pressing up and down arrow keypads to move the arrow on screen to the desired calibration then press SET. Calibration steps which are highlighted (reverse video) on the Calibration Menu must be completed in order to place the machine into the dialysis mode.

To prevent miscalibration, most of the steps on the Calibration Menu have range checking built into the software. If the calibration value that is going to be saved, is not within an acceptable range, the message “OPERATOR ERROR” is displayed on the screen, and the calibration step must be repeated.



FRESENIUS 2008H HEMODIALYSIS SYSTEM

CALIBRATION PROCEDURES

Part Number 500604 Rev. C

FRESENIUS USA, INC.

2637 Shadelands Drive, Walnut Creek, CA 94598

800-227-2572 or 925-295-0200

REGIONAL EQUIPMENT SPECIALIST: _____

FRESENIUS 2008H
HEMODIALYSIS SYSTEM

CALIBRATION
PROCEDURES

Part Number 500604 Rev. C

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WARNINGS

Shock hazard. Refer servicing to qualified personnel.

Never perform maintenance when a patient is connected to the machine. If possible, remove the machine from the treatment area when it is being serviced. Label the machine to ensure it is not accidentally returned to clinical use before the service work is completed. Always fully test the machine when maintenance is completed. Confirm dialysate conductivity and pH level before returning the machine to clinical use.

The electrical source must be 120 volts, 60 Hz, single phase. The outlet must be a three-conductor type with a hospital-grade receptacle and a ground fault interrupter. Test the polarity and ground integrity before installation and ensure it is maintained thereafter. Failure to do so may result in electrical shock to the operator or patient.

Calibration procedures must be performed using primary standards or by using standards that are regularly calibrated in a program traceable to the National Institute of Standards and Technology (National Bureau of Standards).

Calibrate the Level Detector module for the model of venous line being used. During calibration ensure the filter inside the drip chamber is below the sensor heads. Also verify that the venous clamp fully occludes the line when closed.

Failure to install, operate and maintain this equipment according to the manufacturer's instructions may cause injury or death to the patient or the operator.

CALIBRATION PROCEDURES
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NOTE

This document is written for the Fresenius 2008H Hemodialysis System using software versions 8.02 or later.

1.0 INTRODUCTION

Calibration involves doing two things. One is making mechanical adjustments, both to the hydraulics and to the electronics. The other part of calibration is storing data in the electronic memory in the machine. The machine uses battery RAM, which stores calibration data until it is purposely erased and replaced with new data. To store new data in the battery RAM, the machine is operated in Service mode as described in Section 1.2. Service mode also shows important data on the display screen that is needed to make some of the mechanical adjustments.

Perform the calibration procedures only when needed following repairs, or if the machine fails the performance tests included in the Preventive Maintenance Procedures. Do not re-calibrate the machine routinely to verify normal operation. Instead, use the performance tests included in the Preventive Maintenance procedures to ensure the machine is working properly.

If the machine behaves erratically during calibration, perform the Preventive Maintenance procedures. Clogged filters, leaky O-rings and similar items routinely corrected during Preventive Maintenance are a common cause of intermittent problems. When preparing to re-calibrate the Blood Leak Detector, either perform a bleach rinse first or verify that it has been done recently. The bleach rinse is required to clean the detector tube.

1.1 TEST EQUIPMENT NEEDED

The following supplies and test equipment are required to perform of the calibration procedures.

WARNING

All of the test equipment used must be maintained and calibrated regularly in accordance with NIST standards. In particular, the conductivity meter must meet the specifications given below. Failure to do so could result in injury or death to the patient or to the operator.

- Fresenius Test Kit (Fresenius part number 150034), which contains two gauges with fittings and hoses for measuring loading pressure and deaeration pressure.

- Fresenius test connectors containing precision resistors that simulate the thermistor resistance at various temperatures (Fresenius part number 190060).

- Dialysate meter to measure dialysate pressure, temperature and conductivity at the ends of the dialysate lines. The meter must be capable of making pressure measurements of from -250 mmHg to +400 mmHg with an accuracy of at least ±2 mmHg up to ±200 mmHg and an accuracy of at least 1% and ±1 mmHg beyond ±200 mmHg. The temperature function of this meter must be accurate within 0.2°C from 20°C to 45°C and must be capable of measuring dialysate temperatures up to 85°C with an accuracy of at least ±4.0°C. The conductivity function of this meter must be accurate to within 0.1 mS over a range of 12 mS to 17 mS at a temperature of 25°C.

- Stopwatch with a resolution to 0.01 second and an accuracy of 0.01% or better.

- Fresenius Buret, 25 ml capacity with 0.1 ml graduations (Fresenius part number 290104).

- Graduated cylinder: 100 ml capacity with a tolerance of 0.60 ml at 100 ml or better.

- Digital Multimeter to measure dc voltage, ac voltage and resistance with an accuracy of at least 1% + 1 digit for dc voltage measurements 1.5% + 5 digits for ac measurements and 1% + 1 digit for resistance measurements.

- Syringe, 60 cc capacity. Tolerance is not important; the syringe is not used for volume measurements.

- Tachometer capable of measuring shaft speeds up to 2900 rpm with an accuracy of ±3 rpm or better. The tachometer is not required, but is highly recommended to work efficiently.

For machines equipped with the optional blood pressure module, the following equipment is also required to test the module as described in this manual:

- Test Device (Fresenius part number 370090). The Test Device contains two air chambers with calibrated volumes.

- Mercury manometer or equivalent pressure meter accurate to within 1 mmHg at pressures up to 335 mmHg.

1.2 OPERATING MODES

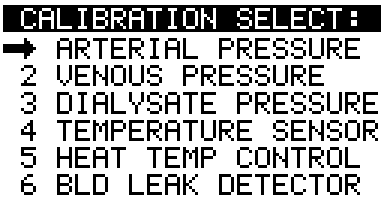
The following calibration procedures contain instructions to place the 2008H into Dialysis Mode and Service Mode. Service Mode is controlled by the red switch on the back of the Monitor Control Unit (Fig. 1) with the recessed toggle. Use a thin blade to change its position.

To place the machine in Service Mode, turn the machine power Off, place the Service switch in the Up position, then turn machine power On again.

NOTE
If the Service switch is changed with the power On, the machine will not switch into Service Mode until the power is turned Off, then On again.

When the machine is in Service Mode, the following screen will appear on the front panel display:

Select CALIBRATION by pressing the front panel Up and Down arrows, then press the SET touchpad. The following menu will appear on the front panel display:



Calibration procedures which are highlighted on the display screen must be completed before the machine will operate in Dialysis mode.

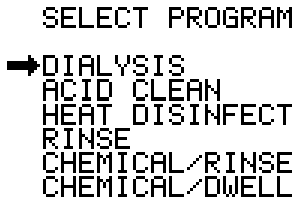
Select the desired calibration by pressing the Up and Down arrows, then press SET to begin the procedure.

CAUTION

Once a calibration procedure is begun, pressing SET usually updates the calibration data in the battery RAM. Be careful not to press SET unless you want to change the calibration data. To leave a calibration procedure without changing the data in battery RAM, press the OVERRIDE touchpad.

A safety feature in the machine helps prevent mis-calibration. In most cases, if a calibration value outside of acceptable limits is entered, the machine will reject the calibration data and the message OPERATOR ERROR will appear on the display screen. The data stored in battery RAM will not be changed if this message appears.

When the machine is not in Service Mode (Service switch is in the down position), the following menu will appear when the machine is turned On:



Press the Up and Down arrows to select DIALYSIS, then press SET to enter Dialysis Mode. For these procedures, the dialysate lines should be in the shunt and the shunt door closed unless otherwise instructed.

Complete instructions for operating the 2008H Hemodialysis System are provided in the Operator Instruction manual, Fresenius part number 490005.

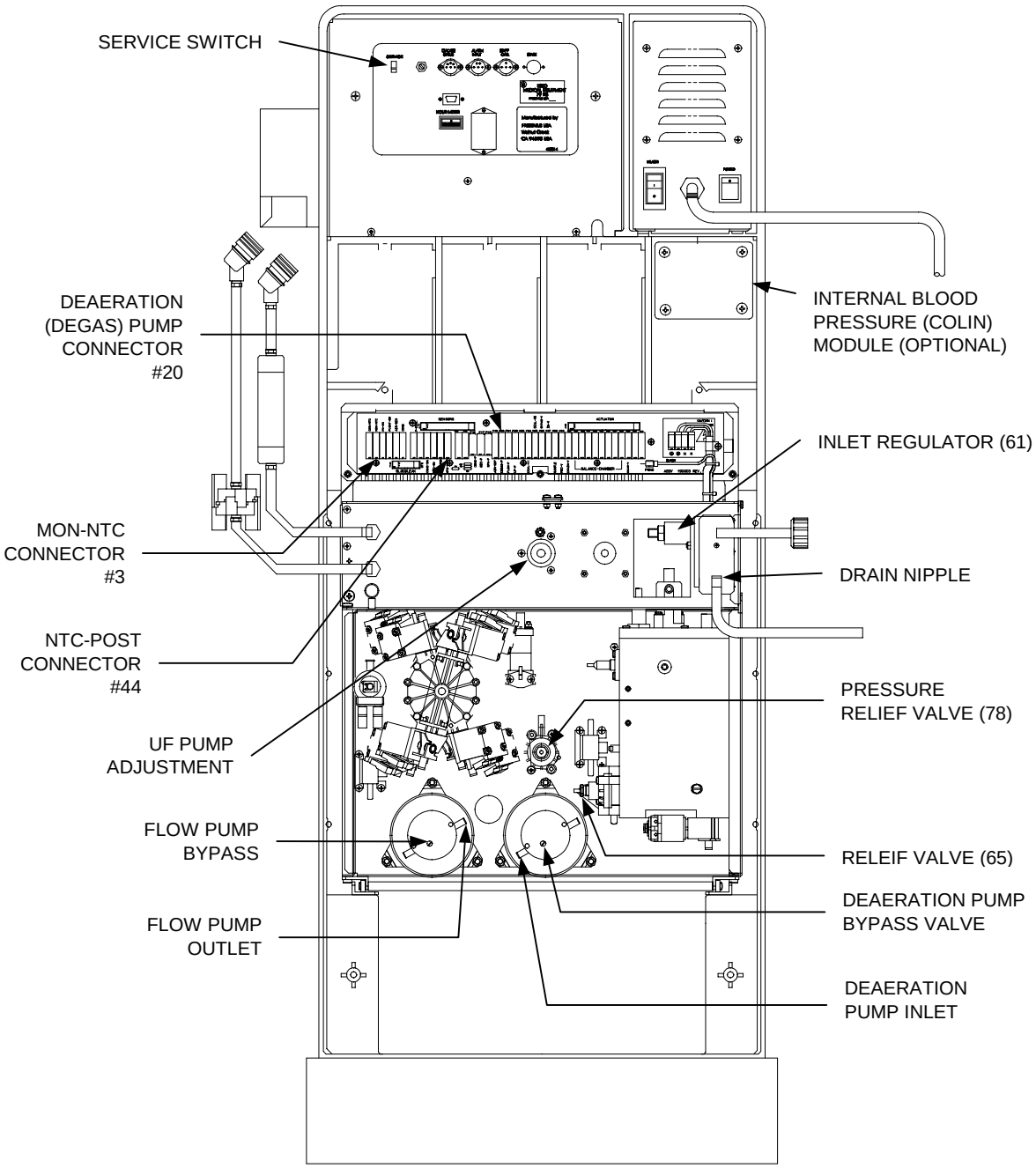


Figure 1. 2008H Rear View.

1.3 MEASURING FLUID VOLUMES

Several of the following procedures require measuring fluid volumes using graduated cylinders and laboratory burets. When making these measurements do the following:

- Make certain the container is clean and dry before collecting the fluid to be measured. Two drops of fluid are approximately 0.1 ml; enough to affect the accuracy of critical measurements.

- Ensure that no items such as thermometers or tubing are allowed to come in contact with the fluid in the graduate. Such items will change the calibration of the graduate and affect the accuracy of measurements. Both the total volume indicated and the amount of fluid indicated by each increment on the graduated scale will be incorrect. For example, if a graduate is calibrated in 1 ml increments, a piece of tubing in contact with the fluid will cause each increment to be *less* than 1 ml, depending upon the total volume of the tubing that penetrates into the fluid.

- Surface tension causes the fluid to curve into a meniscus (Fig. 2). Measure the volume at the bottom of the meniscus curve as shown.

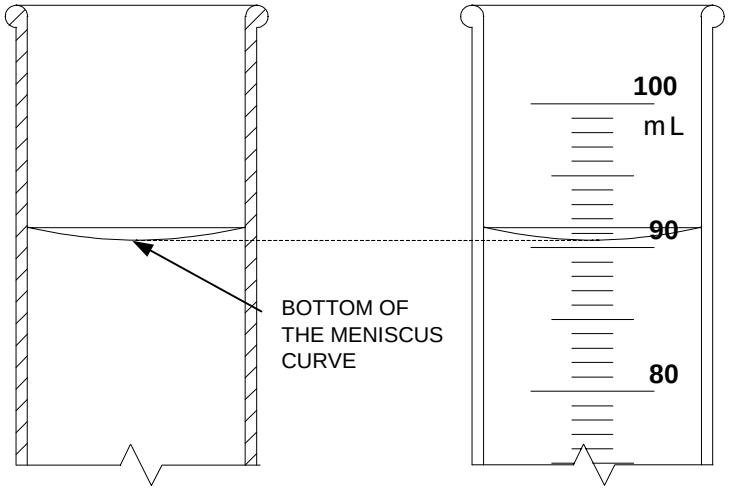


Figure 2. Meniscus Curve

2.0 SERVICE MODE CALIBRATION PROCEDURES

Place the machine in Service Mode as described in Section 1.2 to perform the following procedures. The following calibration procedures are given in the same order as they are found on the CALIBRATION MENU in Service Mode. The procedures do not have to be completed in any particular order. Go directly to the calibration procedures needed.

If calibration is being performed after working on the hydraulics unit, especially if the inlet water pressure regulator has been changed, we recommend that you calibrate the inlet water pressure regulator as described in Section 3.1 first.

2.1 ARTERIAL PRESSURE CALIBRATION

The following procedure calibrates the pressure sensor on the arterial blood pump. If the machine is equipped with both an arterial blood pump and a single needle blood pump, be sure to perform these adjustments on the arterial blood pump identified by the letters $\mathbf{P}_{ART.}$ on the front panel pressure port (Fig. 3).

If the machine is also equipped with a single-needle pump, identified by the letters $\mathbf{P}_{SN}$ on the front panel pressure port, procedures for calibrating it are included along with additional calibration procedures for the arterial blood pump in Section 3.3.

1. With the machine in Service mode, select ARTERIAL PRESSURE on the display screen CALIBRATION menu.

2. Press SET on the front panel. The screen will display:

```
  ARTERIAL PRESSURE
SET TO 0 MMHG
 MMHG  xxx PREPUMP

  ACTUATOR =   xx
```

NOTE
Line 3 of the display screen may read POSTPUMP instead of PREPUMP depending upon the type of bloodlines in use. This is controlled by Dipswitch 3 on the Functional Board.

3. Open arterial transducer port $\mathbf{P}_{ART.}$ on the blood pump module (Fig. 3) to air (atmospheric pressure).

4. Adjust pot 24 on the LP343 board (Fig. 3) so that the MMHG line on the display screen and the PRESSURE ARTERIAL LED display both indicate zero.

5. Press SET. The screen will display:

```
   ARTERIAL PRESSURE
SET TO 200 MMHG
  MMHG  xxx PREPUMP

   ACTUATOR =   xx
```

Some machines will say POSTPUMP instead of PREPUMP as shown above. Make a note of which is indicated on the display screen.

6. Attach a syringe and a calibrated pressure gauge to the $\mathbf{P}_{ART.}$ port using a T- fitting.

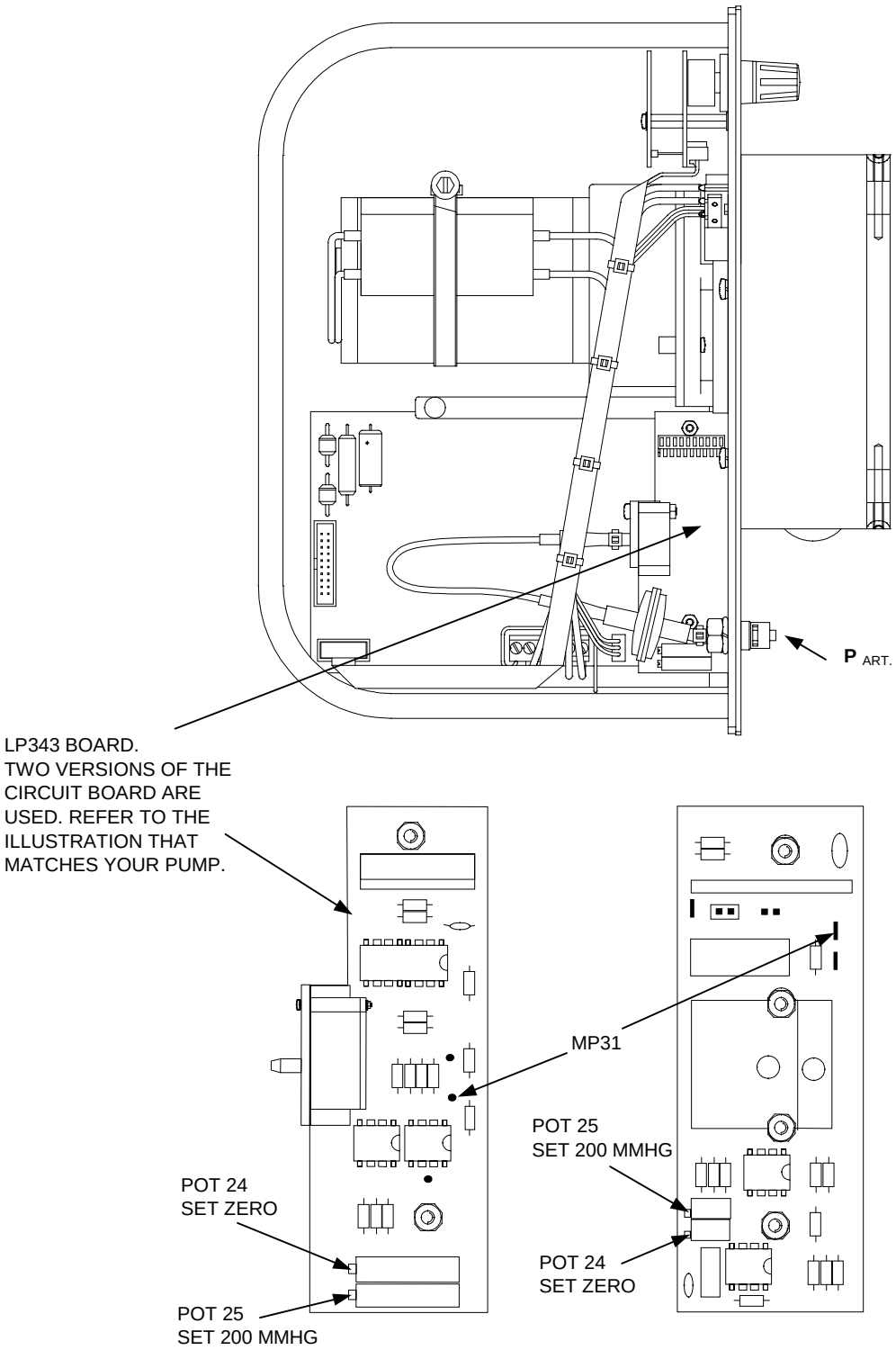


Figure 3. Arterial Pressure Display Adjustments.

7. Push the syringe plunger in to show a pressure of 200 mmHg on the external gauge. While holding this pressure, do the following:

   - Adjust potentiometer 25 on LP343 (Fig. 3) so the display screen indicates MMHG 200.

   - Press SET. The screen will display:

```
   ARTERIAL PRESSURE
CHECK NEGATIVE PRES
  MMHG  xxx PREPUMP

ACTUATOR =    xx
```

   - Verify that the MMHG and ACTUATOR readings on the display screen are within 10 mmHg of each other.

NOTE
After pressing SET, a delay of approximately 8 seconds may occur before the ACTUATOR reading changes to be within 10 mmHg of the MMHG reading on the display screen.

8. Before going on to check the negative pressure as indicated by the display screen, push the syringe plunger in further and verify that the MMHG and ACTUATOR readings on the display screen can reach at least:

   - 290 if the display screen shows PREPUMP.

   - 510 if the display screen shows POSTPUMP.

9. Pull on the syringe plunger to create a negative pressure indicated on the external meter as follows. Verify that the display screen indicates the same pressure within 10 mmHg.

   - -200 if the display screen shows PREPUMP.
   - -80 if the display screen shows POSTPUMP.

10. Pull the syringe plunger further out and verify that the MMHG and ACTUATOR readings on the display screen can reach at least:

    - -310 if the display screen shows PREPUMP.
    - -90 if the display screen shows POSTPUMP.

11. Press SET to save the calibration in the battery RAM. The screen will display:

```
 ARTERIAL PRESSURE
CALIBRATION SAVED
MMHG  xxx PREPUMP

 ACTUATOR =   xx
```

12. Press SET to return to the CALIBRATION menu.

2.2 VENOUS PRESSURE CALIBRATION

1. With the machine in Service mode, select VENOUS PRESSURE on the display screen CALIBRATION menu.

2. Press SET on the front panel. The screen will display:

```
   VENOUS PRESSURE
SET TO 0 MMHG
 MMHG  xxx

  ACTUATOR =   xx
```

3. Open the venous transducer port $\mathbf{P}_{VEN.}$ on the level detector module to air (atmospheric pressure).

4. Adjust the ZERO SET potentiometer (Fig. 4) so that the MMHG line on the display screen and the PRESSURE VENOUS LED display both indicate zero.

5. Press SET. The screen will display:

```
   VENOUS PRESSURE
SET TO 400 MMHG
  MMHG  xxx

  ACTUATOR =   xx
```

6. Attach a syringe and a calibrated pressure gauge to the transducer port using a **T**- fitting.

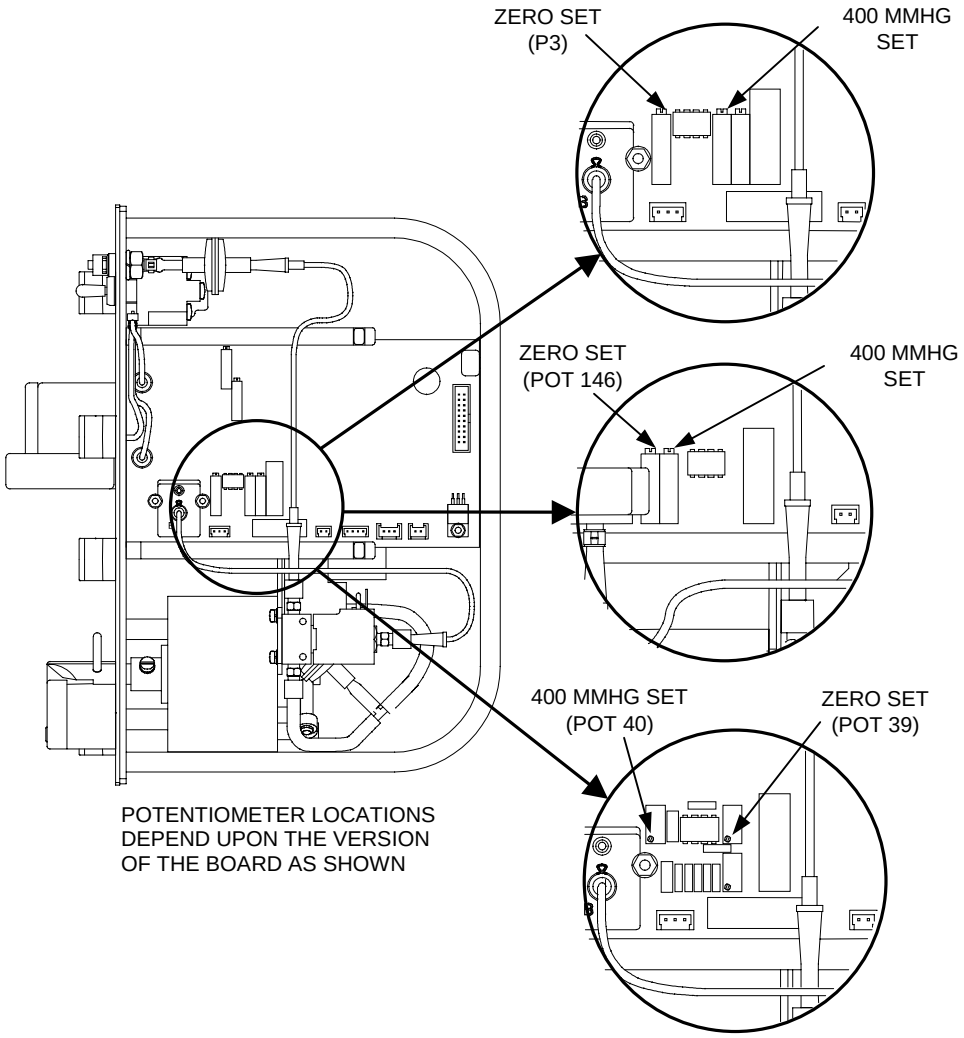


Figure 4. Venous Pressure Display Adjustments.

7. Push the syringe plunger in to show 400 mmHg on the external pressure gauge. While holding this pressure, do the following:

    - Adjust the 400 MMHG SET potentiometer (Fig. 4) so the display screen indicates MMHG 400.

- Press SET. The screen will display:

```
   VENOUS PRESSURE
CHECK NEGATIVE PRES
  MMHG  xxx

   ACTUATOR =   xx
```

- Verify that the MMHG and ACTUATOR readings on the display screen are within 10 mmHg of each other.

NOTE
After pressing SET, a delay of approximately 8 seconds may occur before the ACTUATOR reading changes to be within 10 mmHg of the MMHG reading on the display screen.

8. Before going on to check the negative pressure as indicated by the display screen, push the syringe plunger in further and verify that the MMHG and ACTUATOR readings on the display screen can reach at least 510.

9. Pull on the syringe plunger to create a pressure of -80 mmHg on the external gauge. Verify that the MMHG and ACTUATOR readings display screen and the external gauge all agree within 10 mmHg.

10. Pull the syringe plunger further out and verify that the MMHG and ACTUATOR readings on the display screen can reach at least -90.

11. Press SET to save the calibration in the battery RAM. The screen will display:

```
  VENOUS PRESSURE
CALIBRATION SAVED
MMHG  xxx

   ACTUATOR =   xx
```

12. Press SET again to return to the CALIBRATION menu.

2.3 DIALYSATE PRESSURE CALIBRATION

1. With the machine in Service mode, select DIALYSATE PRESSURE on the display screen CALIBRATION menu.

2. Hang a four-way connector on the I.V. pole at the normal dialyzer height. Remove the dialyzer lines from the shunt and attach them to the connector.

3. Connect a 30 cc syringe to one of the four-way connector outlets and clamp the tubing.

4. Connect a pressure gauge to the remaining four-way connector outlet and clamp the tubing.

5. Press SET. The screen will display:

```
  DIALYSATE PRESSURE
ARE DIALINES FULL?
```

6. Dialysate should be flowing, as indicated by the flow detector in the dialysate lines. Wait until no air is visible passing through the flow indicator, then press the DIALYSATE FLOW touchpad to stop the flow.

7. Unclamp the lines leading to the 30 cc syringe and the pressure gauge.

8. Press SET again. The screen will display:

```
  DIALYSATE PRESSURE
     SET 0 MMHG
A TO D  xx
```

9. Use the syringe to create a pressure reading on the gauge of 0 mmHg. While holding this pressure, press SET. The screen will display:

```
  DIALYSATE PRESSURE
     SET -250 MMHG
A TO D  xx
```

10. Use the syringe to create a pressure reading of -250 mmHg on the gauge. Hold this pressure reading on the test gauge and press and *hold* the front panel SET touchpad until the display screen reads:

```
 DIALYSATE PRESSURE
CALIBRATION SAVED
     xxxx MMHG
```

11. Replace the dialysate lines on the shunt.

12. Press SET to return to the CALIBRATION menu.

2.4 TEMPERATURE SENSOR(S) CALIBRATIONS

If the machine is equipped with the Online Clearance (OLC) option, there are two Temperature Sensor calibrations that must be performed (Section 2.4.1 ***and*** 2.4.2). If the machine is not equipped with OLC, then perform Section 2.4.1 only.

2.4.1 TEMPERATURE SENSOR CALIBRATION

Perform the temperature sensor calibration as follows using the test connector set referenced in Section 1.1. The display screen calls for connecting specific resistances to the MON-NTC connector position on the distribution panel (Fig. 1) for each test. The test connectors contain resistors which are the closest 1% tolerance resistor available to these values. In the following procedure, each test connector is identified by the number marked on its cover.

1. With the machine in Service mode, select TEMPERATURE SENSOR on the display screen CALIBRATION menu.

2. Press the SET touchpad on the front panel. The screen will display:

```
  TEMPERATURE SENSOR
CONNECT 6.808 K OHM
A TO D xxx
```

3. Remove the distribution board cover from the back of the machine.

4. Unplug the MON-NTC connector from the distribution board.

5. Insert test connector 34.

6. Wait for the A TO D reading on the front panel display screen to stabilize, then press SET to store the data in the battery RAM.

7. The screen on the front panel will display:

```
  TEMPERATURE SENSOR
CONNECT 5.117 K OHM
A TO D  xx
```

8. Insert test connector 40.

9. Wait for the A TO D reading on the front panel display screen to stabilize, then press SET to store the data in the battery RAM.

10. The screen on the front panel will display:

```
  TEMPERATURE SENSOR
CONNECT 1.255 K OHM
A TO D  xx
```

11. Insert test connector 80.

12. Wait for the A TO D reading on the front panel display screen to stabilize, then press SET to store the data in the battery RAM.

13. The screen on the front panel will display:

```
  TEMPERATURE SENSOR
CONNECT 0.915 K OHM
A TO D xxx
```

14. Insert the test connector 90.

15. Wait for the A TO D reading on the front panel display screen to stabilize, then press SET to store the data in the battery RAM. The screen on the front panel will display:

```
 TEMPERATURE SENSOR
CALIBRATION SAVED
 42   (37 DEG RANGE)
 90   (80 DEG RANGE)
```

16. Press SET on the front panel to return to the CALIBRATION menu.

17. Remove the test connector and replace the MON-NTC connector on the distribution board.

2.4.2 POST TEMPERATURE SENSOR CALIBRATION (OLC EQUIPPED)

Perform the post temperature sensor calibration as follows using the test connector set referenced in Section 1.1. The display screen calls for connecting specific resistances to the NTC-POST connector position on the distribution panel (Fig. 1) for each test. The test connectors contain resistors which are the closest 1% tolerance resistor available to these values. In the following procedure, each test connector is identified by the number marked on its cover.

NOTE
Machine equipped with the Online Clearance option will have software version 8.35 or greater installed on the Functional Board.

NOTE
If the CLEARANCE option is set to NO, the Post Temperature Sensor calibrations will not be saved.

1. With the machine in Service mode, select POST TEMPER SENSOR on the display screen CALIBRATION menu.

2. Press the SET touchpad on the front panel. The screen will display:

```
  POST TEMPER SENSOR
CONNECT 6.808 K OHM
A TO D  xx
```

3. Remove the distribution board cover from the back of the machine.

4. Unplug the NTC-POST connector from the distribution board.

5. Insert test connector 34.

6. Wait for the A TO D reading on the front panel display screen to stabilize, then press SET to store the data in the battery RAM.

7. The screen on the front panel will display:

```
  POST TEMPER SENSOR
CONNECT 5.117 K OHM
A TO D xxx
```

8. Insert test connector 40.

9. Wait for the A TO D reading on the front panel display screen to stabilize, then press SET to store the data in the battery RAM.

10. The screen on the front panel will display:

```
 POST TEMPER SENSOR
CALIBRATION SAVED
 41  (37 DEG RANGE)
```

11. Press SET on the front panel to return to the CALIBRATION menu.

12. Remove the test connector and replace the NTC-POST connector on the distribution board.

2.5 HEATER TEMPERATURE CONTROL CALIBRATION

If the machine is equipped with the CRRT option, perform Section 2.5.2. If the machine is not equipped with the CRRT option, then perform Section 2.5.1 only.

2.5.1 HEATER TEMPERATURE CONTROL CALIBRATION (NON CRRT EQUIPPED)

1. Replace any panels that have been removed so that the machine is closed up as it would be in normal operation. It is important for this calibration that ventilation around the hydraulics unit be the same as it is when the machine is used for dialysis.

2. With the machine in Service mode, select HEAT TEMP CONTROL on the display screen CALIBRATION menu. Press the SET touchpad on the front panel. The screen will display:

```
HEAT TEMP CONTROL
TYPE: FRESENIUS
```

3. Press the Up or Down arrow keypads to display the type of concentrate being used, then press the SET touchpad. The screen will display:

```
   HEAT TEMP CONTROL
ADJUST FOR 37 DEGREES

 CAL TEMP DAC ?xxx
MONITOR  xx.x DEGREES
```

4. Connect the Red and Blue concentrate connectors to concentrate solutions as in normal dialysis operation.

5. Remove the dialysate lines from the shunt and connect them to an external temperature meter. Close the shunt door.

6. Press the Up or Down arrow touchpads on the front panel to change the CAL TEMP DAC? value shown on the display screen. The temperature of the dialysate shown on the external meter will also change after a delay. Find the CAL TEMP DAC? value that produces a temperature on the external meter of 37°C.

> **NOTE**
> Changing the DAC value by 4 or 5 units will produce a temperature change of about 0.1°C. Wait for the temperature to change and stabilize before changing it again to avoid overshooting the proper setting.

7. Wait five minutes after the last adjustment of the CAL TEMP DAC? value, then verify that the temperature on the external meter has remained at 37°C. If not, repeat step 6, and wait five minutes again.

8. Unplug the MON-NTC connector from the distribution board (Fig. 1).

9. Verify that the value shown for MONITOR xx.x DEGREES is 33 or less.

10. Insert test connector 80 in the MON-NTC plug position on the distribution board (Fig. 1).

11. Verify that the value shown for MONITOR xx.x DEGREES is 41 or greater.

12. Remove the test connector 80 and reconnect the MON-NTC connector.

13. Press SET on the front panel. The screen will display:

```
   HEAT TEMP CONTROL
ADJUST FOR 37 DEGREES

 CAL TEMP DAC  xxx
MONITOR ?xx.x DEGREES
```

14. Press the Up or Down arrow touchpads on the front panel until the value shown for MONITOR xx.x DEGREES matches the external temperature meter at 37°C.

15. Press SET on the front panel to store the data in the battery RAM. The screen will display:

```
  HEAT TEMP CONTROL
 CALIBRATION SAVED

 CAL TEMP DAC  xxx
MONITOR  xx.x DEGREES
```

16. Open the shunt to stop the dialysate flow, remove the lines from the external meter and replace them on the shunt.

17. Press SET again to return to the CALIBRATION menu.

2.5.2 HEATER TEMPERATURE CONTROL CALIBRATION (CRRT EQUIPPED)

When the machine is equipped with the CRRT option, the HEAT TEMP CONTROL calibration is done in two parts. The DAC and temperature monitor calibration is performed at 500 ml/min flow rate and then it is calibrated at a 100 ml/min flow rate.

1. Replace any panels that have been removed so that the machine is closed up as it would be in normal operation. It is important for this calibration that ventilation around the hydraulics unit be the same as it is when the machine is used for dialysis.

2. With the machine in Service mode, select HEAT TEMP CONTROL on the display screen CALIBRATION menu. Press the SET touchpad on the front panel. The screen will display:

```
HEAT TEMP CONTROL
TYPE: FRESENIUS
```

3. Press the Up or Down arrow keypads to display the type of concentrate being used, then press the SET touchpad. The screen will display:

```
   HEAT TEMP CONTROL
ADJUST FOR 37 DEGREES
 USING FLOW RATE 500
 CAL TEMP DAC ?xxx
MONITOR  xx.x DEGREES
POST NTC xx.x DEGREES
```

The HEAT TEMP CONTROL calibration begins with the flow at 500ml/min as indicated on the screen above.

4. Connect the Red and Blue concentrate connectors to concentrate solutions as in normal dialysis operation.

5. Remove the dialysate lines from the shunt and connect them to an external temperature meter. Close the shunt door.

6. Press the Up or Down arrow touchpads on the front panel to change the CAL TEMP DAC? value shown on the display screen. The temperature of the dialysate shown on the external meter will also change after a delay. Find the CAL TEMP DAC? value that produces a temperature on the external meter of 37°C.

> **NOTE**
> Changing the DAC value by 4 or 5 units will produce a temperature change of about 0.1°C. Wait for the temperature to change and stabilize before changing it again to avoid overshooting the proper setting.

7. Wait five minutes after the last adjustment of the CAL TEMP DAC? value, then verify that the temperature on the external meter has remained at 37°C. If not, repeat step 6, and wait five minutes again.

8. Unplug the MON-NTC connector from the distribution board (Fig. 1).

9. Verify that the value shown for MONITOR xx.x DEGREES is 33 or less.

10. Insert test connector 80 in the MON-NTC plug position on the distribution board (Fig. 1).

11. Verify that the value shown for MONITOR xx.x DEGREES is 41 or greater.

12. Remove the test connector 80 and reconnect the MON-NTC connector.

13. Press SET on the front panel. The screen will display:

```
   HEAT TEMP CONTROL
ADJUST FOR 37 DEGREES
 USING FLOW RATE 500
 CAL TEMP DAC  xxx
MONITOR xx.x DEGREES
POST NTC xx.x DEGREES
```

14. Press the Up or Down arrow touchpads on the front panel until the value shown for MONITOR xx.x DEGREES matches the external temperature meter at 37°C.

15. Press SET on the front panel. The screen will display:

```
   HEAT TEMP CONTROL
ADJUST FOR 37 DEGREES
 USING FLOW RATE 100
 CAL TEMP DAC ?xxx
MONITOR  xx.x DEGREES
POST NTC xx.x DEGREES
```

The HEAT TEMP CONTROL calibration now changes the flow to 100ml/min as indicated on the screen above.

16. Press the Up or Down arrow touchpads on the front panel to change the CAL TEMP DAC? value shown on the display screen. The temperature of the dialysate shown on the external meter will also change after a delay. Find the CAL TEMP DAC? value that produces a temperature on the external meter of 37°C. Be patient, the 100ml/min flow rate calibration takes time.

NOTE

Depending on the incoming water temperature, the DAC value during the 100ml/min flow calibration may have to be set to the maximum (255). If the temperature is less than 37°C, the DAC value is at 255, and enough time has passed, go ahead and save the DAC value of 255. This circumstance will be compensated for in dialysis or CRRT modes.

17. Wait five minutes after the last adjustment of the CAL TEMP DAC? value, then verify that the temperature on the external meter has remained at 37°C. If not, repeat step 16, and wait five minutes again.

18. Press SET on the front panel. The screen will display:

```
   HEAT TEMP CONTROL
ADJUST FOR 37 DEGREES
 USING FLOW RATE 100
 CAL TEMP DAC  xxx
MONITOR xx.x DEGREES
POST NTC xx.x DEGREES
```

19. Press the Up or Down arrow touchpads on the front panel until the value shown for MONITOR xx.x DEGREES matches the external temperature meter at 37°C.

20. Press SET on the front panel to store the data in the battery RAM. The screen will display:

```
   HEAT TEMP CONTROL
  CALIBRATION SAVED
 USING FLOW RATE 100
 CAL TEMP DAC  xxx
MONITOR  xx.x DEGREES
POST NTC xx.x DEGREES
```

21. Open the shunt to stop the dialysate flow, remove the lines from the external meter and replace them on the shunt.

22. Press SET again to return to the CALIBRATION menu.

2.6 BLOOD LEAK CALIBRATION

The glass tube in the blood leak detector must be clean before the blood leak detector and blood leak dimness calibrations can be completed successfully. The glass tube in the detector is cleaned by performing a bleach rinse, which washes the tube out along with the rest of the hydraulics. Verify that the machine has received a bleach rinse recently, or perform a bleach rinse as described in the Operator's Manual before calibrating the blood leak detector.

There are two calibrations performed on the Blood Leak Detector. One calibrates the detector itself and the other calibrates the dimness circuits. Perform the procedures as described below.

2.6.1 BLOOD LEAK DETECTOR

1. With the machine in Service mode, select BLD LEAK DETECTOR on the display screen CALIBRATION menu.

2. Press SET on the front panel. The screen will display:

```
BLD LEAK DETECTOR
SET TARGET VOLTAGE

TARGET 4.99 VOLTS
```

3. Press the Up or Down arrow touchpads, if necessary, until the screen displays a TARGET value of 4.99 VOLTS.

4. Press SET. The screen will display:

```
BLD LEAK DETECTOR
AUTO CALIBRATING
      x.xx VOLTS
TARGET 4.99 VOLTS
```

5. Wait until the screen displays:

```
BLD LEAK DETECTOR
    FINISHED
     4.99 VOLTS
TARGET 4.99 VOLTS
```

6. Press SET again to store the data in the battery RAM. The screen will display:

```
 BLD LEAK DETECTOR
CALIBRATION SAVED
     4.99 VOLTS
TARGET 4.99 VOLTS
```

7. Press SET again to return to the CALIBRATION menu.

2.6.2 BLOOD LEAK DIMNESS CALIBRATION

1. With the machine in Service mode, select BLOOD LEAK DIMNESS on the CALIBRATION menu.

2. Press SET on the front panel. The screen will display:

```
BLD LEAK DET DIM
AUTO CALIBRATING
     x.xx VOLTS
```

3. Wait until the screen displays:

```
BLD LEAK DET DIM
    FINISHED
     4.99 VOLTS
```

4. Press SET to store the data in the battery RAM. The screen will display:

```
 BLD LEAK DET DIM
CALIBRATION SAVED
     4.99 VOLTS
```

5. Press SET again to return to the CALIBRATION menu.

2.7 BALANCE CHAMBER VOLUME CALIBRATION

The balance chamber volume is measured at the factory with a high degree of accuracy using equipment usually not available in the field. The chamber volume will not change in use. Record the factory-measured chamber volume for reference should the value need to the replaced in the battery RAM. Only perform the following procedure if the factory measured volume has been lost, or if the balance chamber has been repaired or replaced.

1. With the machine in Service mode, select BAL CHAMBER VOLUME on the CALIBRATION menu.

2. Press SET on the front panel. The screen will display:

```
BAL CHAMBER VOLUME
OPTIONAL PRIMING?
```

NOTE

Be prepared to remove the drain hose from the back of the machine (Fig. 1) and to collect fluid from the drain nipple with an empty 100 ml graduated cylinder.

3. Press SET. The screen will display:

```
BAL CHAMBER VOLUME
PREPARING TO PRIME
```

Followed by:

```
BAL CHAMBER VOLUME
    PRIMING
```

The machine will automatically fill the balance chambers with fluid.

4. The screen will display:

```
   BAL CHAMBER VOLUME
PREPARING TO CALIBRAT
```

Remove the drain hose from the back of the machine. Approximately 25 seconds after the above message appears the contents of the balancing chambers will be dispensed from the drain nipple with two pulses of fluid. Catch this fluid in the empty graduated cylinder. While this process is going on, the screen will display:

```
BAL CHAMBER VOLUME
  CALIBRATING
```

When the two pulses have been dispensed, the screen will display:

```
BAL CHAMBER VOLUME
xx.x ML
```

5. Place the graduated cylinder on a level surface and read the volume of fluid it contains.

6. Press the Up or Down arrow keypads until the display screen indicates the amount collected in the graduated cylinder.

7. Press SET to store the data in the battery RAM. The screen will display:

```
BAL CHAMBER VOLUME
CALIBRATION SAVED
xx.x ML
```

8. Replace the drain hose on the outlet nipple.

9. Press SET again to return to the CALIBRATION menu.

2.8 ACID (CONCENTRATE) PUMP VOLUME CALIBRATION

1. With the machine in Service mode, select ACID PUMP on the CALIBRATION menu.

2. Press SET on the front panel. The screen will display:

```
   ACID PUMP VOLUME
FILL CONCENTRATE WAND
```

3. Fill a 25 ml buret with treated water or concentrate.

4. Attach the buret to the red concentrate line with a piece of tubing.

5. Press PRIME on the front panel. The pump will begin stroking and the number of strokes will be displayed:

```
   ACID PUMP VOLUME
FILL CONCENTRATE WAND
PRIMING  xx STROKES
```

6. Allow the pump to stroke about 20 times to remove the air from the line, then press PRIME again to stop the pump. The screen will display:

```
   ACID PUMP VOLUME
FILL CONCENTRATE WAND
```

CAUTION
Be sure the buret did not run out of fluid and allow air to be pulled into the machine.

7. Refill the buret exactly to the full (0 mL) mark.

8. Press SET. The pump will stroke and the number of strokes will be shown on the display screen:

```
ACID PUMP VOLUME
      xx STROKES
```

9. After 30 strokes, press SET again to stop the pump. The screen will display:

```
ACID PUMP VOLUME
     xx.x ML
```

10. Measure the amount of fluid that was removed from the buret. The volume removed should be between 15 and 20 ml.

11. Press the Up or Down arrow keypads if needed to change the volume shown on the display screen until it agrees with the amount removed from the buret. Press SET. The screen will display:

```
  ACID PUMP VOLUME
FILL CONCENTRATE WAND
```

12. Refill the buret exactly to the full (0 mL) mark.

13. Press SET. The pump will stroke and the number of strokes will be shown on the display screen:

```
ACID PUMP VOLUME
      xx STROKES
```

14. When the fluid nears the bottom to the buret, but is still within the graduated area, press SET again to stop the pump. The screen will display the volume of acid pumped based on the number of pump strokes multiplied by a default value for the volume pumped by each stroke:

```
ACID PUMP VOLUME
     xx.x ML
```

15. Measure the amount of fluid that was removed from the buret.

16. Press the Up or Down arrow keypads if needed to correct the volume shown on the display screen until it agrees with the amount removed from the buret.

17. Press SET to store the data in the battery RAM. The screen will display:

```
ACID PUMP VOLUME
CALIBRATION SAVED
```

18. Press SET again to return to the CALIBRATION menu.

2.9 BICARBONATE PUMP VOLUME CALIBRATION

1. With the machine in Service mode, select BICARBONATE PUMP on the CALIBRATION menu.

2. Press SET on the front panel. The screen will display:

```
   BIC PUMP VOLUME
FILL BICARBONATE WAND
```

3. Fill a 25 ml buret with treated water or concentrate.

4. Attach the buret to the blue bicarbonate line with a piece of tubing.

5. Press PRIME on the front panel. The pump will begin stroking and the number of strokes will be displayed:

```
   BIC PUMP VOLUME
FILL BICARBONATE WAND
PRIMING  xx STROKES
```

6. Allow the pump to stroke about 20 times to remove the air from the line, then press PRIME again to stop the pump. The screen will display:

```
   BIC PUMP VOLUME
FILL BICARBONATE WAND
```

CAUTION
Be sure the buret did not run out of fluid and allow air to be pulled into the machine.

7. Refill the buret exactly to the full (0 ml) mark.

8. Press SET. The pump will stroke and the number of strokes will be shown on the display screen:

```
BIC PUMP VOLUME
      xx STROKES
```

9. After 30 strokes, press SET again to stop the pump. The screen will display:

```
BIC PUMP VOLUME
     xx.x ML
```

10. Measure the amount of fluid that was removed from the buret. The volume removed should be between 15 and 20 ml.

11. Press the Up or Down arrow keypads if needed to change the volume shown on the display screen until it agrees with the amount removed from the buret. Press SET. The screen will display:

```
BIC PUMP VOLUME
FILL BICARBONATE WAND
```

12. Refill the buret exactly to the full (0 mL) mark.

13. Press SET. The pump will stroke and the number of strokes will be shown on the display screen:

```
BIC PUMP VOLUME
      xx STROKES
```

14. When the fluid nears the bottom to the buret, but is still within the graduated area, press SET again to stop the pump. The screen will display the volume of bicarbonate based on the number of pump strokes multiplied by a default value for the volume pumped by each stroke:

```
BIC PUMP VOLUME
     xx.x ML
```

15. Measure the amount of fluid that was removed from the buret.

16. Press the Up or Down arrow keypads if needed to correct the volume shown on the display screen until it agrees with the amount removed from the buret.

17. Press SET to store the data in the battery RAM. The screen will display:

```
BIC PUMP VOLUME
CALIBRATION SAVED
```

18. Press SET again to return to the CALIBRATION menu.

2.10 UF PUMP VOLUME CALIBRATION

1. With the machine in Service mode, select UF PUMP VOLUME on the CALIBRATION menu. Press SET. The screen will display:

```
UF PUMP VOLUME
PUT LINES IN WATER
```

2. Remove the dialysate lines from the shunt and place them in a bucket of water.

3. Remove the tubing from the FLUID SAMPLE / ULTRA-FILTRATE OUTPUT port on the front panel and connect it to a 25 ml buret. Open the buret stopcock.

4. Fill the line and the bottom of the buret with fluid as follows (Fig. 5):

   - Press SET on the front panel. The screen will display:

```
UF PUMP VOLUME
SET GOAL STROKES

GOAL STROKES:   24
```

   - Press the Up or Down arrow touchpads to select GOAL STROKES 24 on the display screen.

   - Press SET. The UF pump will begin operating and fluid should be pumped into the buret.

- When fluid appears, press OVERRIDE on the front panel to stop the pump. The screen will return to the CALIBRATION menu and display:

```
 CALIBRATION SELECT:
  7 BLD LEAK DET DIM
  8 BAL CHAMBER VOLUME
  9 ACID PUMP VOLUME
 10 BIC PUMP VOLUME
 11 UF PUMP VOLUME
 ➡ CONDUCTIVITY CELL
```

- Press the Up arrow to select UF PUMP VOLUME on the CALIBRATION menu again.

- Press SET to return to the following screen:

```
   UF PUMP VOLUME
PUT LINES IN WATER
```

- Add or remove fluid from the buret so the meniscus is exactly on the 25 ml mark (Fig. 5).

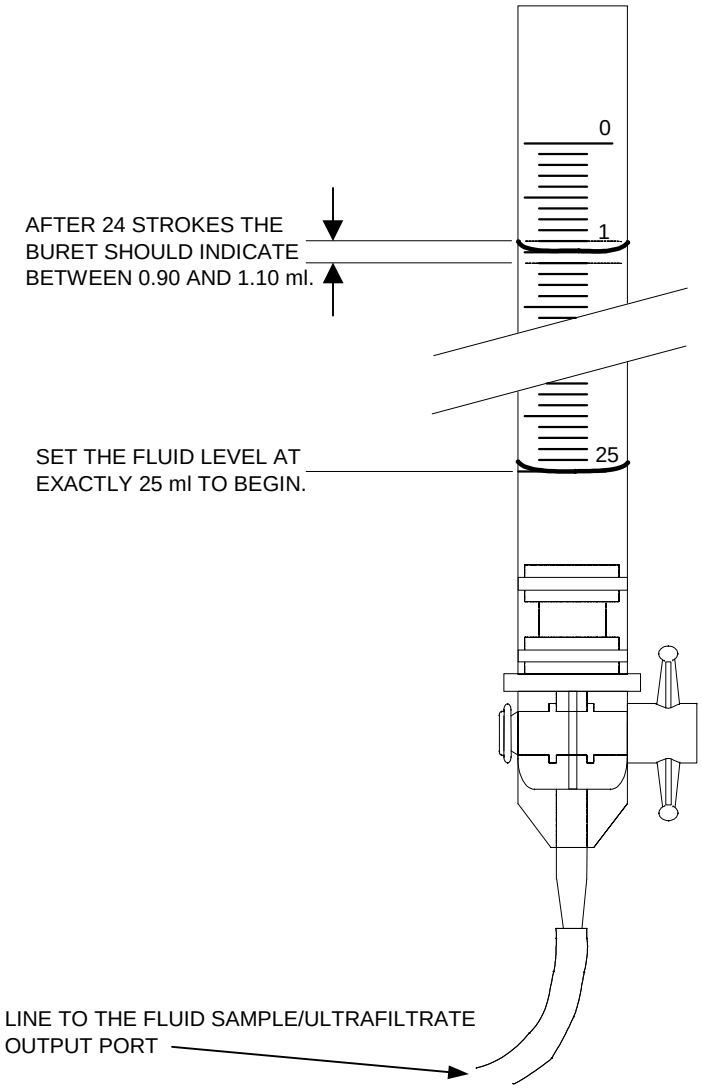


Figure 5. UF Pump Volume Measurement.

5. Press SET on the front panel. The screen will display:

```
UF PUMP VOLUME
SET GOAL STROKES

GOAL STROKES:   24
```

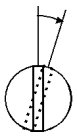
6. Press the Up or Down arrow touchpads to select GOAL STROKES 24 on the display screen.

7. Press SET. The UF pump will begin operating and the strokes completed are shown on the display screen. After exactly 24 strokes, the pump will stop.

8. Measure the fluid collected in the buret. The buret scale should indicate between 0.90 and 1.10 ml, indicating that between 23.90 and 24.10 ml of fluid was collected (Fig. 5). If correct, press SET. If the volume collected is not within this range, adjust the UF pump volume as follows:

   - On the rear center of the hydraulics assembly, remove the plastic cap covering the pump adjustment screw (Fig. 1).

   - Loosen the locking nut and turn the screw clockwise to decrease or counter-clockwise to increase the pump volume.



NOTE

Turning the adjustment screw approximately the width of the screwdriver slot will change the amount of fluid collected in 24 strokes by about 0.25 ml. After adjusting pump, run prime pump.

   - Tighten the locking nut before proceeding.

   - Press the Up arrow to select UF PUMP VOLUME on the CALIBRATION menu again.

- Press SET to return to the following screen:

```
UF PUMP VOLUME
PUT LINES IN WATER
```

- Repeat steps 3 through 8 until the fluid fills the buret to between 0.90 and 1.10 on the scale after 24 strokes of the UF pump.

9. Replace the plastic cap on the UF pump adjustment.

2.11 CONDUCTIVITY CELL(S) CALIBRATIONS

If the machine is equipped with the Online Clearance (OLC) option, perform Section 2.11.2. If the machine is not equipped with the Online Clearance (OLC) option, then perform Section 2.11.1 only.

2.11.1 CONDUCTIVITY CELL CALIBRATION (NON OLC EQUIPPED)

1. With the machine in Service mode, select CONDUCTIVITY CELL on the CALIBRATION menu.

2. Press SET on the front panel. The screen will display:

```
CONDUCTIVITY CELL
TYPE: FRESENIUS
```

NOTE
If using software version 8.35 or later, this screen will list all concentrates entered in the machine. Select the concentrate being used during calibration, then press SET.

3. Connect jug(s) of the concentrate normally used to the machine.

4. Press the Up or Down arrow touchpads, if necessary, to display the concentrate being used on the screen.

5. Connect the dialysate lines to an external conductivity meter.

NOTE
If using the Automata Neo-1 meter, attach the ground strap per the manufacturer's instructions.

6. Press SET. The screen will display:

```
  CONDUCTIVITY CELL
WAITING UNTIL STABLE

UNCAL READ     xx.xx
```

7. Wait 10 minutes for the conductivity to stabilize. The screen will display:

```
  CONDUCTIVITY CELL
READING IS STABLE

UNCAL READ     xx.xx
ADJUST VALUE   xx.xx
```

NOTE
If the machine has been running without concentrate the machine may report that the reading is stable on the display screen too soon. Wait until a stable reading in a normal conductivity range is obtained.

8. Press the Up or Down touchpads to change the ADJUST VALUE shown on the display screen until it matches the reading on the external conductivity meter.

9. Press SET on the front panel to save the data in the battery RAM. The screen will display:

```
   CONDUCTIVITY CELL
  CALIBRATION SAVED

UNCAL READ     xx.xx
ADJUST VALUE   xx.xx
```

10. Disconnect the calibration meter and replace the dialysate lines in the shunt.

11. Press SET on the front panel again to return to the CALIBRATION menu.

2.11.2 POST CONDUCTIVITY CELL CALIBRATION (OLC EQUIPPED)

Machines equipped with the Online Clearance option have two conductivity cells. The first conductivity cell is "PRE" dialyzer and the second conductivity cell is "POST" dialyzer.

NOTE
Machine equipped with the Online Clearance option will have software version 8.35 or greater installed on the Functional Board.

NOTE
If the CLEARANCE option is set to NO in HARDWARE OPTIONS, the Post Conductivity Cell will not be calibrated.

1. With the machine in Service mode, select CONDUCTIVITY CELLS on the CALIBRATION menu.

2. Press SET on the front panel. The screen will change to show all of the selected concentrates.

3. Press the Up or Down arrow touchpads to move the arrow to the concentrate you are using to calibrate the conductivity. Do not press the SET keypad yet.

4. Connect jug(s) of the concentrate normally used to the machine.

5. Connect the dialysate lines to an external conductivity meter.

NOTE
If using the Automata Neo-1 meter, attach the ground strap per the manufacturer's instructions.

6. Press SET. The screen will display:

```
   CONDUCTIVITY CELL
 WAITING UNTIL STABLE

UNCAL READ     xx.xx
```

7. Wait 10 minutes for the conductivity to stabilize. The screen will display:

```
   CONDUCTIVITY CELL
  READING IS STABLE

UNCAL READ     xx.xx
ADJUST VALUE   xx.xx
```

NOTE
If the machine has been running without concentrate the machine may report that the reading is stable on the display screen too soon. Wait until a stable reading in a normal conductivity range is obtained.

8. Press the Up or Down touchpads to change the ADJUST VALUE shown on the display screen until it matches the reading on the external conductivity meter.

9. Press SET. The screen will display:

```
   CONDUCTIVITY CELLS
  READ FIRST POINT

CALIB READ     xx.xx
```

10. The machine is now adjusting to its first reference point of conductivity.

11. When the reference conductivity is stable, the display will change to the following:

```
   CONDUCTIVITY CELLS
  READ SECOND POINT

CALIB READ     xx.xx
```

12. The machine is now adjusting to a second reference point of conductivity.

13. When the conductivity is stable again, the display will change to the following:

```
    CONDUCTIVITY CELLS
PRESS SET KEY TO SAVE

CALIB READ     xx.xx
```

14. Press SET on the front panel to save the data in the battery RAM.

15. The display will confirm the saved calibration:

```
CONDUCTIVITY CELLS
CALIBRATION SAVED

CALIB READ    xx.xx
```

16. Disconnect the calibration meter and replace the dialysate lines in the shunt.

17. Press SET on the front panel again to return to the CALIBRATION menu.

2.12 VOLT HI LO DETECT CALIBRATION

1. Open the monitor unit and connect a Digital Voltmeter between the +12 volt test and the ground test points shown in Figure 6.

2. With the machine in Service mode, select VOLT HI LO DETECT on the CALIBRATION menu.

3. Press SET on the front panel. The screen will display:

```
VOLT HI LO DETECT

VOLTAGE =   xx.x
A-TO-D  =    xxx
5V EST. =   x.xx
12V EST.=  xx.xx
```

4. Press the Up or Down arrow touchpads until the VOLTAGE = line indicates the voltage shown on the digital voltmeter.

5. Verify that the 5V EST. = displayed on the screen is between 4.8 and 5.2 volts.

6. Press SET to save the data in the battery RAM.

7. Verify that the 12V EST. = displayed on the screen is within 0.1 volt of the value shown in the Digital Voltmeter.

```
   VOLT HI LO DETECT
  CALIBRATION SAVED
VOLTAGE =   xx.x
A-TO-D  =    xxx
5V EST. =   x.xx
12V EST.=  xx.xx
```

NOTE
The 12V EST will not change to the new value until the machine is powered off then back on

8. Disconnect the Digital Voltmeter and close the monitor unit.

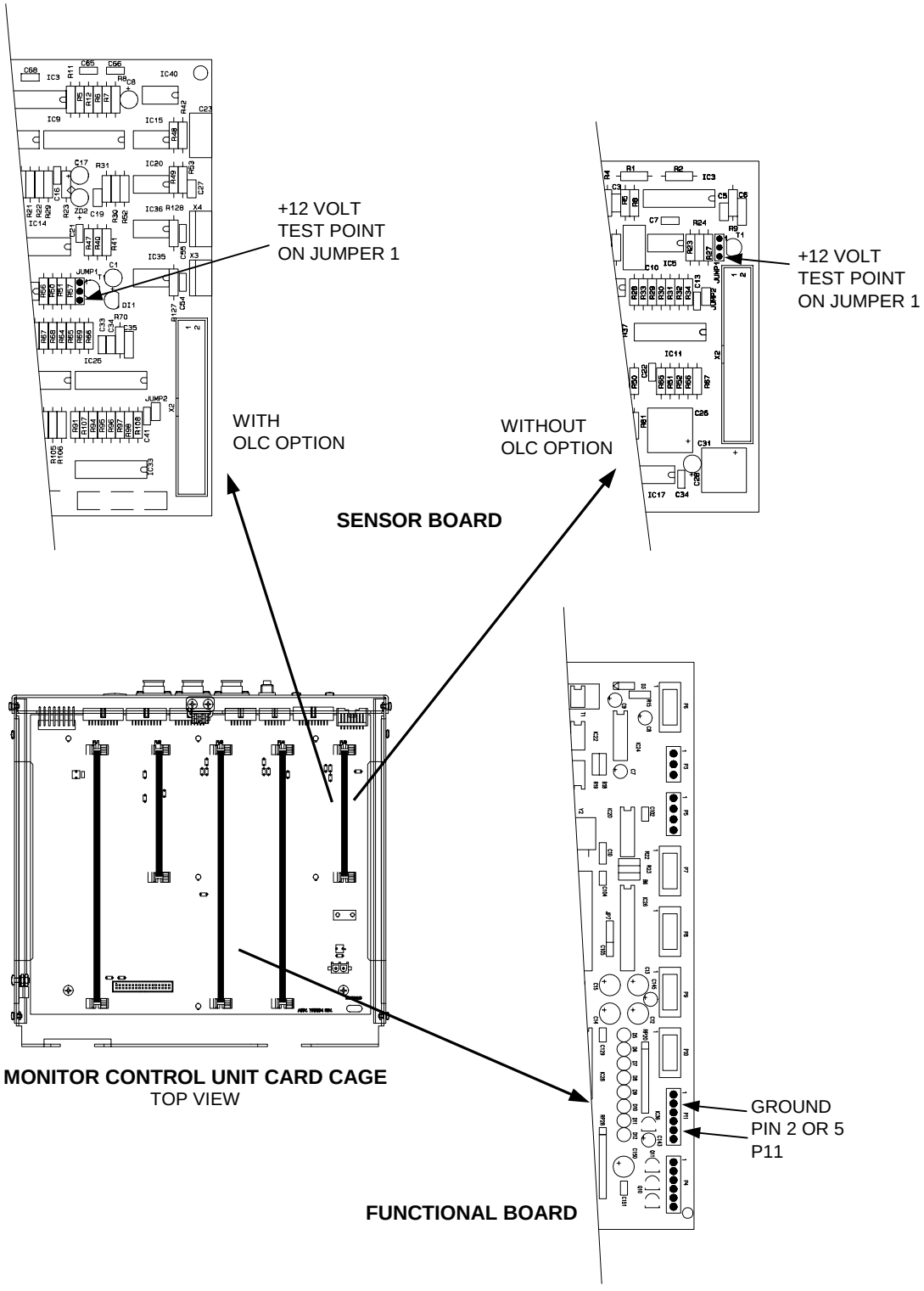


Figure 6. +12 Volt and Ground Test Points.

2.13 DEAERATION AND LOADING PRESSURE CALIBRATION

1. With the machine in Service mode, select DEAERATION PRESSURE on the CALIBRATION menu.

2. Press SET on the front panel. The screen will display:

```
  DEAERATION PRESSURE
ARE GAUGES CONNECTED?
```

3. Connect a gauge in line at the inlet side of the deaeration pump (Fig. 1).

NOTE
The inlet side is the side with clear plastic line. The pressure side of the pump has a white reinforcing jacket over the line.

4. Connect a gauge equipped with a yellow connector into the red RINSE port.

5. Press SET again. The screen will display:

```
DEAERATION PRESSURE
PUMP RATE: xxx
```

6. Press the Up or Down arrow touchpads to set the PUMP RATE value on the display screen at 180.

7. Adjust the bypass valve (Fig. 1) on the deaeration pump for a reading of -24 inHg on the gauge attached to the deaeration pump. The gauge needle will be wiggling slightly. Set the pressure so the maximum value is -24 inHg and verify that the needle does not go below -25 inHg. If these values cannot be reached, set the bypass valve for the closest reading possible, then press the Up arrow touchpad to increase the PUMP RATE value until the proper pressure is indicated on the gauge.

8. The loading pressure gauge in the red RINSE port will be cycling between two pressure levels. Adjust pressure relief valve #65 (Fig. 1) for a reading between 18 and 20 psi when the gauge is reading its highest pressure level. Verify that the pressure is greater than 10 psi at the lowest level, and that it is stable within 1 psi at each level.

> **NOTE**
> If a DIASAFE® filter system is installed, adjust pressure relief valve #65 for a reading between 23 and 25 psi when the gauge is reading its highest pressure level.

9. Repeat steps 8 and 9 until both readings are correct without further adjustment.

10. Press SET on the front panel to record the data in the battery RAM. The screen will display:

```
DEAERATION PRESSURE
CALIBRATION SAVED
 PUMP RATE: xxx
```

11. Remove the gauges.

12. Press SET on the front panel to return to the CALIBRATION menu.

2.14 FLOW RELIEF PRESSURE CALIBRATION

1. With the machine in Service mode, select FLOW PRESSURE RELIEF on the CALIBRATION menu.

2. Press SET on the front panel. The screen will display:

```
FLOW RELIEF PRESSURE
IS GAUGE CONNECTED?
```

3. Connect a pressure gauge in line at the output of the flow pump.

4. Locate the flow bypass screw on the back of the flow pump (Fig. 1). Turn the flow bypass screw all the way in (clockwise), then back it out two turns.

5. Press SET on the front panel. The screen will display:

```
FLOW RELIEF PRESSURE
  ADJUST PRESSURE
```

6. Adjust pressure relief valve #78 (Fig. 1) for a pressure between 29 and 30 psi indicated on the gauge.

> **NOTE**
> If a DIASAFE® filter system is installed, adjust pressure relief valve #78 for a pressure between 35 and 36 psi.

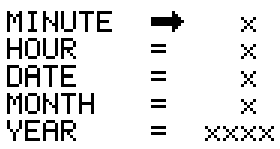
7. Press SET on the front panel to return to the CALIBRATION menu.

8. Remove the gauge from the flow pump output.

2.15 SET CLOCK

1. With the machine in Service mode, select SET CLOCK on the CALIBRATION menu.

2. Press SET on the front panel. The screen will display:



3. Set each value as follows:

   - Press the Up or Down arrow touchpads to select the value to be changed.
   - Press SET. The cursor changes into a ?
   - Press the Up or Down arrow touchpads to set the value.
   - Press RESET to save the data in battery RAM.

2.16 FILL FOR SHIPPING

This is for factory use only, although it is included in the CALIBRATION menu. When machines are shipped they are filled with sterilant and FILL FOR SHIPPING is selected. Once SET is pressed, the machine will not operate until it has been passed through a complete rinse cycle. This ensures that all sterilant is flushed from the machine before it can be used. If you press SET while FILL FOR SHIPPING is selected you must pass through a complete rinse cycle before proceeding.

2.17 BLOOD PRESSURE MODULE (COLIN) TEST

If the machine is equipped with an internal blood pressure module (Fig. 1), the display screen CALIBRATION menu will include a TEST COLIN MODULE selection. There are no adjustments or calibration that can be done on the blood pressure module. This menu selection is used during Preventive Maintenance to test the blood pressure module for normal operation. The test procedure is included in the 2008H Hemodialysis System Preventive Maintenance Procedures manual.

NOTE
The name Colin refers to the manufacturer of the blood pressure module used in the Fresenius 2008H machine.

2.18 ARTERIAL PUMP RATE

1. With the machine in Service mode, select ART PUMP RATE on the CALIBRATION menu.

2. Press SET on the front panel. The screen will display:

```
ART PUMP RATE

SET PUMP RATE TO 100
THEN PRESS SET

A-TO-D =     xx
```

3. Adjust the arterial pump rate to 100ml/min.

4. Press SET on the front panel. The screen will display:

```
ART PUMP RATE

SET PUMP RATE TO 400
THEN PRESS SET

A-TO-D =    xxx
```

5. Adjust the arterial pump rate to 400ml/min.

6. Press SET on the front panel. The screen will indicate that the arterial pump rate calibration has been saved.

```
   ART PUMP RATE
  CALIBRATION SAVED
SET PUMP RATE TO 400
THEN PRESS SET
CURRENT RATE =    xxx
    A-TO-D =    xxx
```

7. Press SET to return to the CALIBRATION menu.

2.19 VENOUS PUMP RATE

1. With the machine in Service mode, select VEN PUMP RATE on the CALIBRATION menu.

2. Press SET on the front panel. The screen will display:

```
   VEN PUMP RATE

SET PUMP RATE TO 100
THEN PRESS SET

    A-TO-D =     xx
```

3. Adjust the venous pump rate to 100ml/min.

4. Press SET on the front panel. The screen will display:

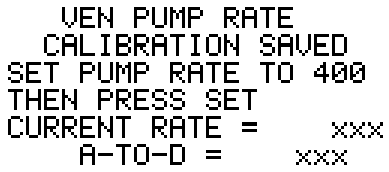
```
   VEN PUMP RATE

SET PUMP RATE TO 400
THEN PRESS SET

    A-TO-D =    xxx
```

5. Adjust the venous pump rate to 400ml/min.

6. Press SET on the front panel. The screen will indicate that the venous pump rate calibration has been saved.



7. Press SET to return to the CALIBRATION menu.

3.0 CALIBRATION PROCEDURES NOT PERFORMED IN SERVICE MODE

The following procedures are performed with the machine in normal (not Service mode) operation (see Section 1.2).

CAUTION
Verify that the machine power is Off before changing the position of the SERVICE mode switch on the back of the Monitor Control Unit. Failure to do so may cause calibration data to be lost.

3.1 INLET WATER PRESSURE REGULATOR CALIBRATION

1. Turn off the machine.
2. Shut off the water supply to the machine.
3. Insert a pressure gauge in the water line at the outlet of water inlet pressure regulator #61 (Fig. 1).

CAUTION
Use tie wraps or tubing clamps to secure the connections. The water pressure may be sufficient to blow the lines off of the gauge if they are not secured.

4. Turn the water supply to the machine On.
5. Turn the machine On.
6. With the dialysate lines in the shunt, select Dialysis mode and start the dialysate flow. The pressure gauge will cycle between two readings as water inlet valve opens and closes.

7. On regulator #61, loosen the lock nut around the adjustment screw (Fig. 1). Use a 5mm Allen wrench to adjust the regulator for a peak pressure of between 18 and 20 psi when water inlet valve 41 is closed.

NOTE
The gauge must indicate a minimum pressure greater than 8 psi when valve 41 is open. If not, the treated water supply may not meet specifications for flow and pressure.

8. Tighten the lock nut and verify the peak pressure is still between 18 and 20 psi on the gauge.

9. Turn the machine Off, turn off the source water supply, remove the gauge and reconnect the tubing using clamps to prevent leaks.

10. Turn the treated water supply source On, turn the machine On and select Dialysis mode. Start dialysate flow and inspect all hoses and connections for leaks.

3.2 LEVEL DETECTOR CALIBRATION

1. Place the machine in Dialysis mode and clear all blood alarms.

2. Insert a venous chamber filled with warm water into the level detector.

> **WARNING**
> For accurate calibration, use a venous chamber identical to that normally used in the machine.

3. Move the jumper on the LP241/LP450 board to the Calibrate position (Fig. 7).

4. Observe the Channel 1 LED (Fig. 7). If the LED is On, turn channel 1 potentiometer (Fig. 7) clockwise until the LED turns off.

5. Slowly turn channel 1 potentiometer counter-clockwise until the channel 1 LED switches on. Stop turning immediately, just past the point where the LED lights.

6. Repeat Steps 5 and 6 for the Channel 2 LED, adjusting channel 2 potentiometer (Fig. 7). The response of channel 2 is slower than channel 1. When adjusting to the switch point, move the potentiometer in small steps and wait to see if the LED switches on.

7. Move the jumper back to the Normal position (Fig. 7).

8. Press RESET to clear the alarm and check that both LED's are off, indicating that the Level Detector is sensing no air present in the venous chamber.

9. Remove the venous chamber and watch the LED's. Verify that channel 1 lights first followed quickly by channel 2.

> **NOTE**
> Channel 1 stops the blood pump and Channel 2 clamps the venous blood line.

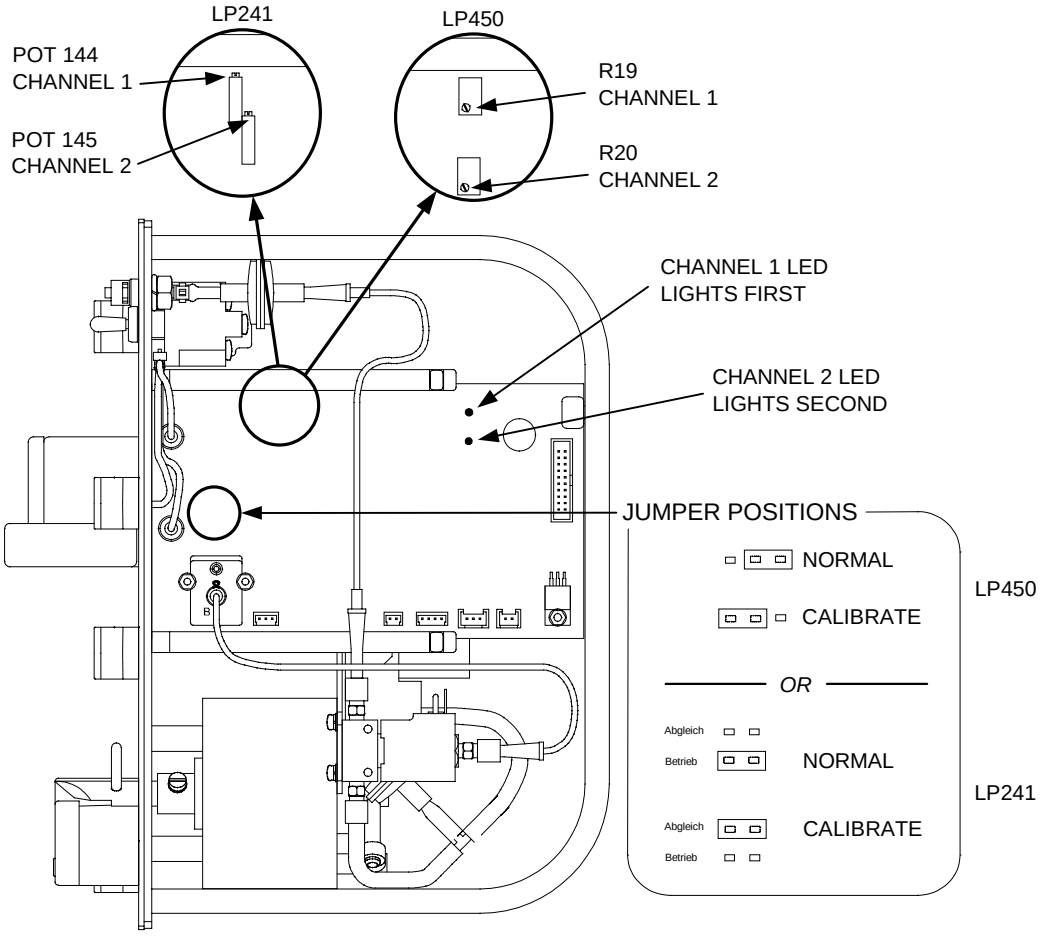


Figure 7. Level Detector Calibration Adjustments.

3.3 BLOOD PUMP CALIBRATION

Calibrating the Arterial Blood Pump consists of the following:

- Setting the pump head speed accurately, either by measuring the time required for the pump head to make 10 revolutions or by measuring the shaft speed of the pump motor.
- Adjusting the speed compensation circuit so the pump head speed will remain constant even though the load on the pump changes.
- Adjusting a voltage generated internally by the pump that is used by the display circuit.
- Adjusting the display circuit to indicate the proper pump rate for a given pump head speed.
- Adjusting the pump motor control so the pump will stop if set below a rate of 35 ml/min.
- Testing the pump to ensure the outlet pressure into a closed line does not exceed 30±5 psi at a pump rate of 600 ml/min.

NOTE
Setting the pump head speed is the most accurate method of calibrating the pump in a clinical environment and meets Fresenius standards for accuracy and consistency of calibration between machines. Do not attempt to calibrate the pump by pumping a quantity of fluid and measuring the flow rate. Such measurements require precise control of pressures and temperatures to achieve acceptable results.

A Single-Needle Blood Pump has an additional steps to calibrate the upper and lower pressure limits at which the pump stops. These steps are at the end of the following procedure.

Perform the calibration for either an Arterial or Single-Needle Blood Pump as follows:

1. Place the machine in Dialyze mode and clear all blood alarms.

2. Set the blood line tubing size selector to 8 mm (Fig. 8).

3. Remove the blood line segment from the blood pump.

4. Adjust the front panel speed control (Fig. 8) for a motor shaft speed of 1903±30 rpm or until the pump head makes 10 complete rotations in 14.66±0.25 seconds.

> **NOTE**
> When timing the pump head rotation, be sure to measure *complete* rotations of the pump head. The symmetrical design of the pump head makes it easy to count half-turns by mistake. If necessary, place a mark on the pump head to use as a reference point.

5. Place the blood line pump segment in place and close the door to restart the pump motor.

> **NOTE**
> Leave the size selector set to 8 mm until instructed otherwise, even though the blood line segment is of a different size. Calibrating the pump for 8 mm tubing ensures calibration at all other tubing size settings of the selector.

6. Measure the motor shaft speed or the time required for the pump head to complete 10 rotations again. If the speed has changed, adjust the SPEED LOAD COMPENSATION potentiometer on the LP340 board (Fig. 9) until the speed matches that measured in step 4.

7. Repeat steps 2 through 7 until the time required for 10 rotations of the pump head varies less than 0.2 seconds or the motor shaft speed varies less than 15 rpm with or without the blood line pump segment in place.

8. Adjust the front panel speed control (Fig. 8) for a motor shaft speed of 1903±30 rpm or until the pump head makes 10 complete rotations in 14.66±0.25 seconds.

9. Connect a digital voltmeter to R75 on the LP340 board (+) and MP207 or TP207 (–) (Fig. 9).

10. Adjust the 7.5V SET potentiometer on the LP340 board for a reading of 7.50 volts on the digital voltmeter.

11. Open the front door to stop the pump.

12. Adjust the ZERO SET potentiometer on circuit board LP342 (Fig. 8) counterclockwise until the front panel display shows:

13. Slowly turn the ZERO SET potentiometer in the clockwise direction until the front panel display shows:

14. Turn the ZERO SET potentiometer an additional 1/4 turn in the same direction.

15. Close the blood pump door to restart the pump.

NOTE
If the front door is left open too long, (either 15 or 30 seconds, depending upon the time delay chosen at installation) a blood alarm will have occurred. Press the RESET button on the Monitor Control Unit front panel to clear the alarm and start the pump.

16. Confirm the motor shaft speed is still spinning at 1903±30 rpm or the pump head is making 10 complete rotations in 14.66±0.25 seconds as set in step 8 above.

17. Adjust the SET 450 potentiometer on LP342 (Fig. 8) as required so the display indicates:

18. Open the door to stop the pump and check the display. Repeat steps 12 through 17 until the display indicates 000 with the door open and 450 with the door closed.

19. Adjust the pump speed control until the front panel display indicates:

20. Adjust the LOW SPEED LIMIT potentiometer on LP340 (Fig 9) so the pump just stops rotating.

NOTE
If the pump starts at a speed faster than 30, adjust the LOW SPEED LIMIT potentiometer so the pump will start at 40 and is stopped at speeds less than 40.

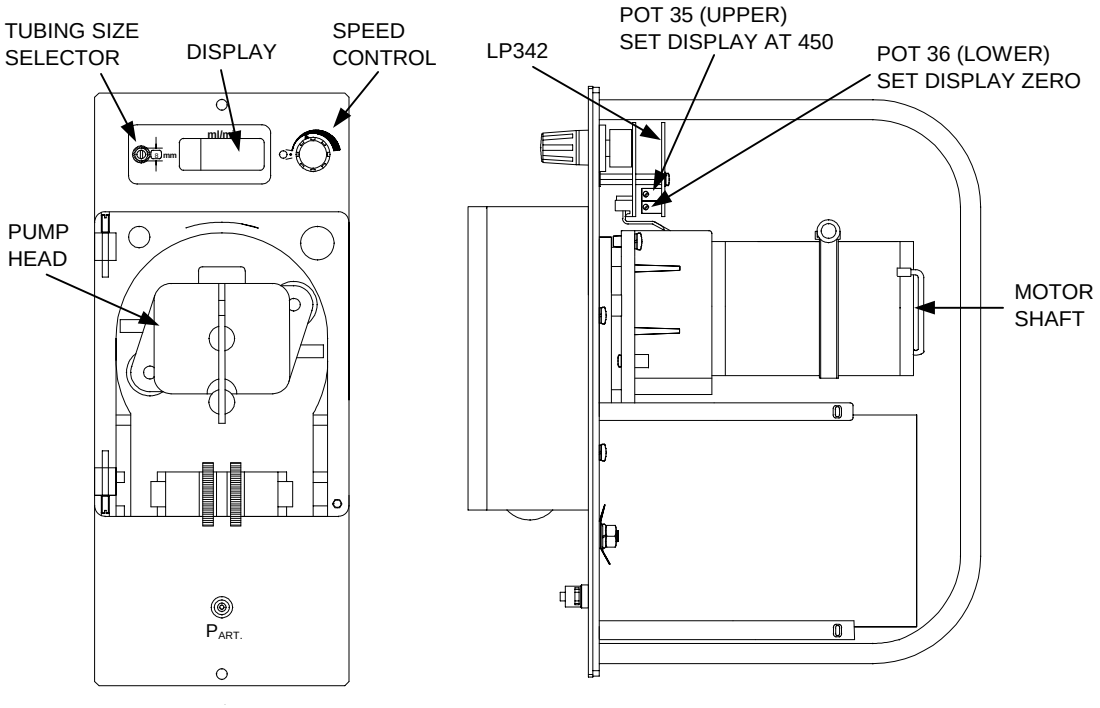


Figure 8. Arterial Blood Pump Adjustments - Part 1.

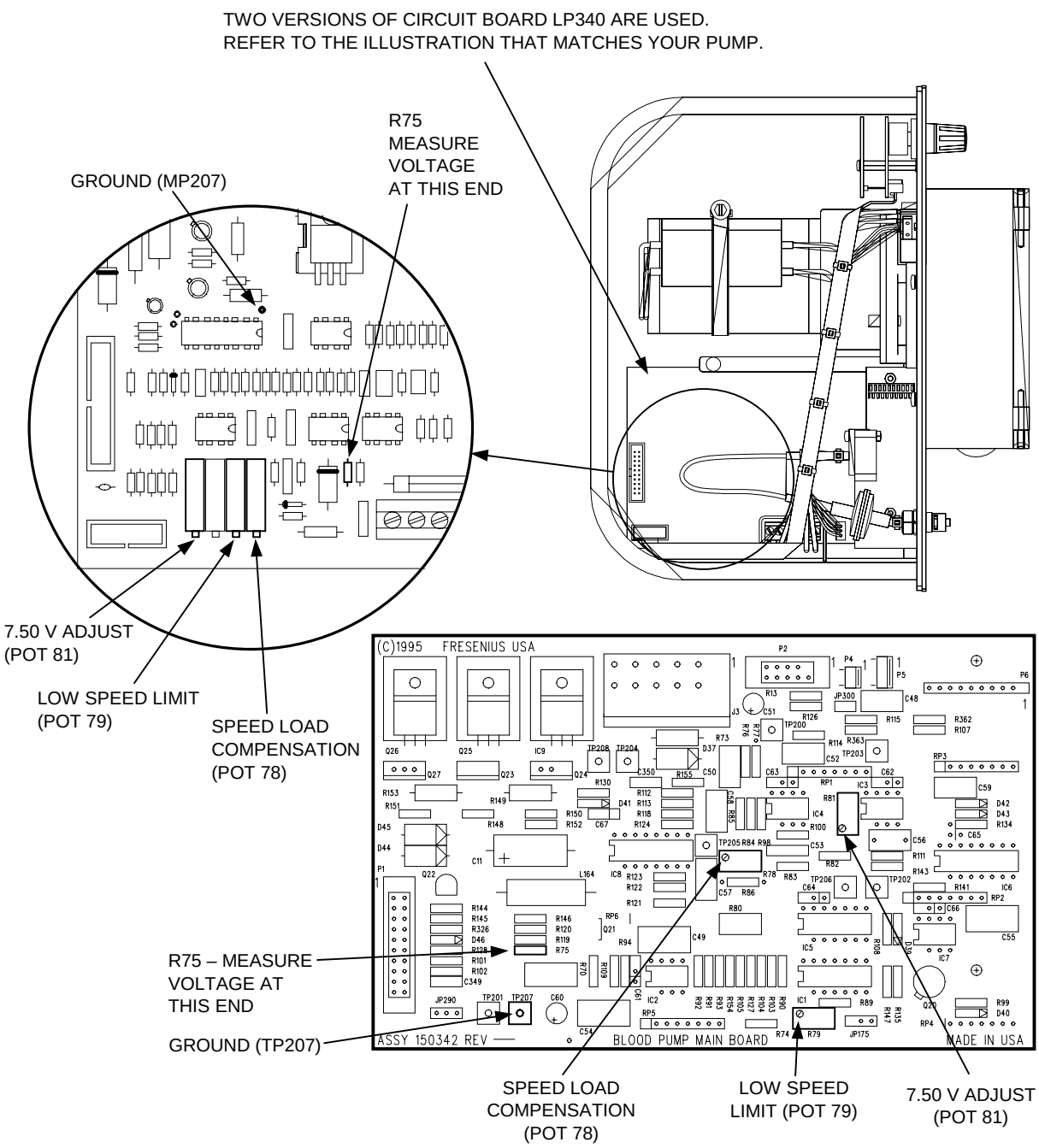


Figure 9. Arterial Blood Pump Adjustments - Part 2.

The calibration of an Arterial Blood Pump is completed. For a Single-Needle pump, perform the following:

1. Connect a digital voltmeter to MP31 on the LP340 board (+) (Fig 10) and ground at MP207 or TP207 on the LP340 board (Fig. 9).

   NOTE
   The blood line may be removed from the pump head to make the unit easier to handle, if desired.

2. Clear the blood alarm created when testing the alarm delay (above) and restart the pump.

3. With the $\mathbf{P}_{SN}$ pressure port open to air, adjust potentiometer 24 (Fig. 10) for a reading of 0.00 to 0.03 vdc on the digital voltmeter.

4. Attach tubing with a **Y**-fitting to the $\mathbf{P}_{SN}$ port. Connect a syringe and a pressure meter to the tubing.

5. Increase the pressure to 225 mmHg and clamp the line to hold the pressure.

6. With the pressure at 225 mmHg, adjust potentiometer 25 on LP343 (Fig. 10) for an indication of 2.70 vdc.

7. Use the syringe to vary the pressure while watching the arterial and single needle pumps. Verify that the pumps start and stop as follows:

PRESSURE	ARTERIAL PUMP	SINGLE-NEEDLE PUMP
> 180 mmHG	STOPPED	RUNNING
< 80 mmHG	RUNNING	STOPPED

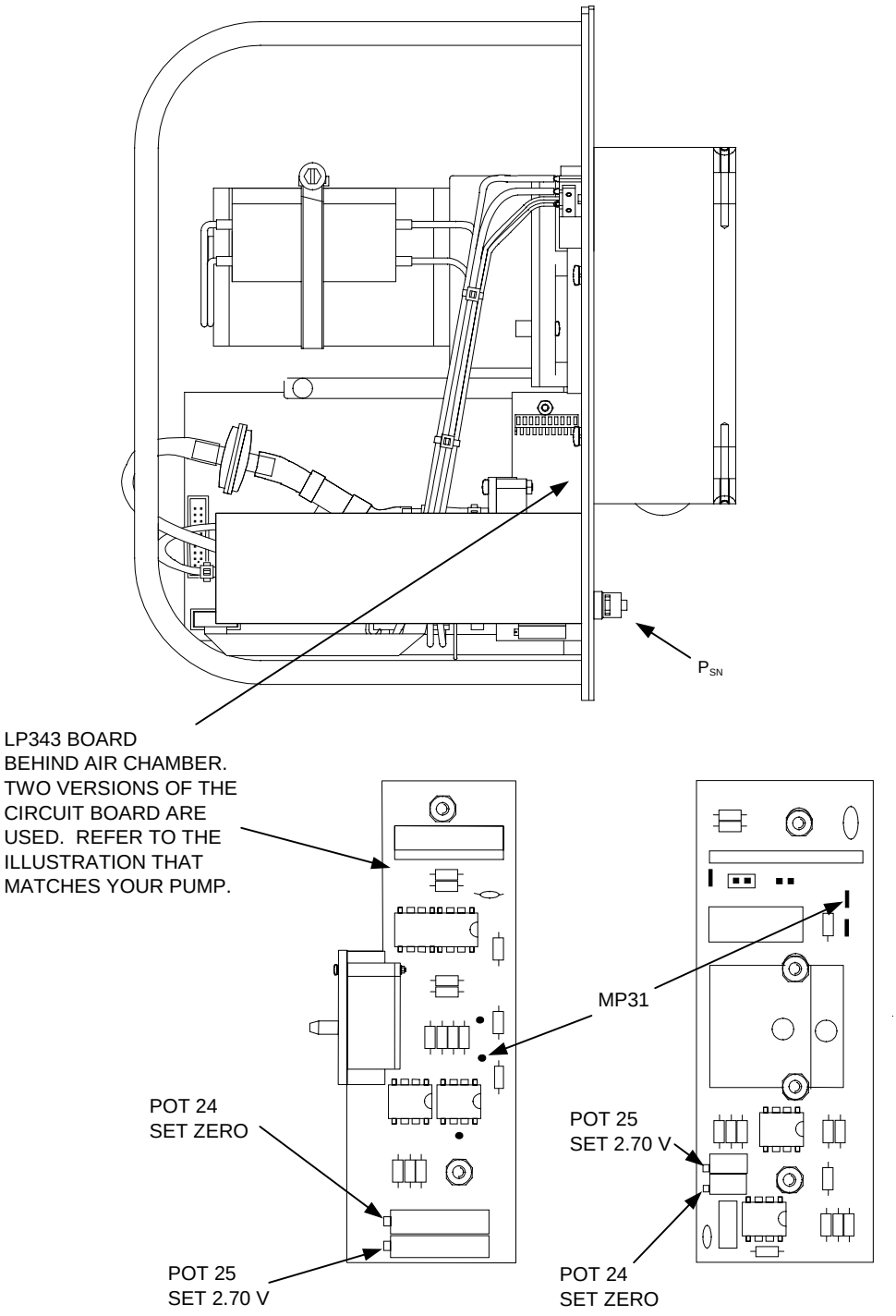


Figure 10. Single-Needle Blood Pump Adjustments.

4.0 APPENDICES

4.1 APPENDIX A - ENTERING CONCENTRATES

The 2008H can store in non-volatile memory up to 10 different concentrates for use in the dialysis mode. These can be selected from a series that is programmed at the factory, or can be customized by the user by entering them manually. The steps used for both of these approaches will be covered here.

4.1.1 SELECTION FROM THE PROGRAMMED LIST

1. From the OPTIONS Menu of Service mode, select ENTER CONCENTRATES using the up and down arrow keypads.

2. Press SET and using the up and down arrow keypads select a concentrate "family". The choices are ACETATE, FRESENIUS, COBE, and DRAKE. The COBE family also has selections for the bicarbonate strength in grams/liter and mEq/L. Use the arrow keypads and SET to select these variables.

   NOTE
   Since different manufacturers of dialysis machines use different proportioning ratios in their ACID/BICARBONATE systems, the 2008H will only accept one bicarbonate family. If you choose a new family it will delete the concentrates from the previous family.

3. The screen displays the list of pre-programmed concentrates of the family that has been selected. To select an individual acid or acetate concentrate, move the cursor to the desired concentrate using the up and down arrow keypads, and press SET. Concentrates that have been selected will appear highlighted (reverse video). To deselect a concentrate, move the cursor to the desired concentrate using the up and down arrow keypads, and press SET. The deselected concentrate will change from highlighted to normal.

4. After all the concentrates have been selected, press RESET to exit that screen and save the concentrates in memory.

4.1.2 MANUAL ENTRY OF CONCENTRATES

To use concentrates that are not included in the pre-programmed list, all of the individual components must be entered.

1. From the OPTIONS Menu of Service mode, select ENTER CONCENTRATES using the up and down arrow keypads.

2. Press SET and using the up and down arrow keypads select a concentrate "family". The choices are ACETATE, FRESENIUS, COBE, and DRAKE. The COBE family also has selections for the bicarbonate strength in grams/liter and mEq/L. Use the arrow keypads and SET to select these variables.

> **NOTE**
> Since different manufacturers of dialysis machines use different proportioning ratios in their ACID/BICARBONATE systems, the 2008H will only accept one bicarbonate family. If you choose a new family it will delete the concentrates from the previous family.

3. The screen displays the list of pre-programmed concentrates of the family that has been selected. Move the arrow to the bottom of the list and select ADD CON by pressing SET.

4. Enter the name of the acid or acetate concentrate. (The bicarbonate information was automatically stored when the family was selected.) Press SET The cursor changes to a ? and the first letter of the concentrate name is highlighted. Change the letter or number by using the up and down arrow keypads. When the desired letter or number is displayed, press the right arrow keypad and the second letter of the name will be highlighted. The name of the concentrate can be up to six letters and/or numbers.

5. After the last letter or number has been chosen, press SET. The cursor changes back to an arrow and the concentrate constituents can be entered. Move the cursor to the constituent to be changed and press SET. The cursor changes to a ? and the value can be changed using the arrow keypads. The values of Sodium (NA), Potassium (K), Calcium (CA), Magnesium (MG), Acetic Acid (AC), (AC is used for Sodium Acetate if acetate dialysis is being used), and Chloride (CL) are expressed in mEq/L, and the values for Dextrose (DX) is expressed in mg%.

NOTE

Some concentrate manufacturers express the value of Sodium as the final amount in the dialysate including the amount from the bicarbonate stream. The value for Sodium (NA) that is to be entered here is just the amount that is in the acid stream.

When the desired value has been entered, press SET. Continue entering the values for all of the constituents. Press RESET to exit this screen and save the data in memory.

NOTES:

NOTES:

NOTES:

NOTES:

NOTES:

COMMON CONVERSIONS

PRESSURE

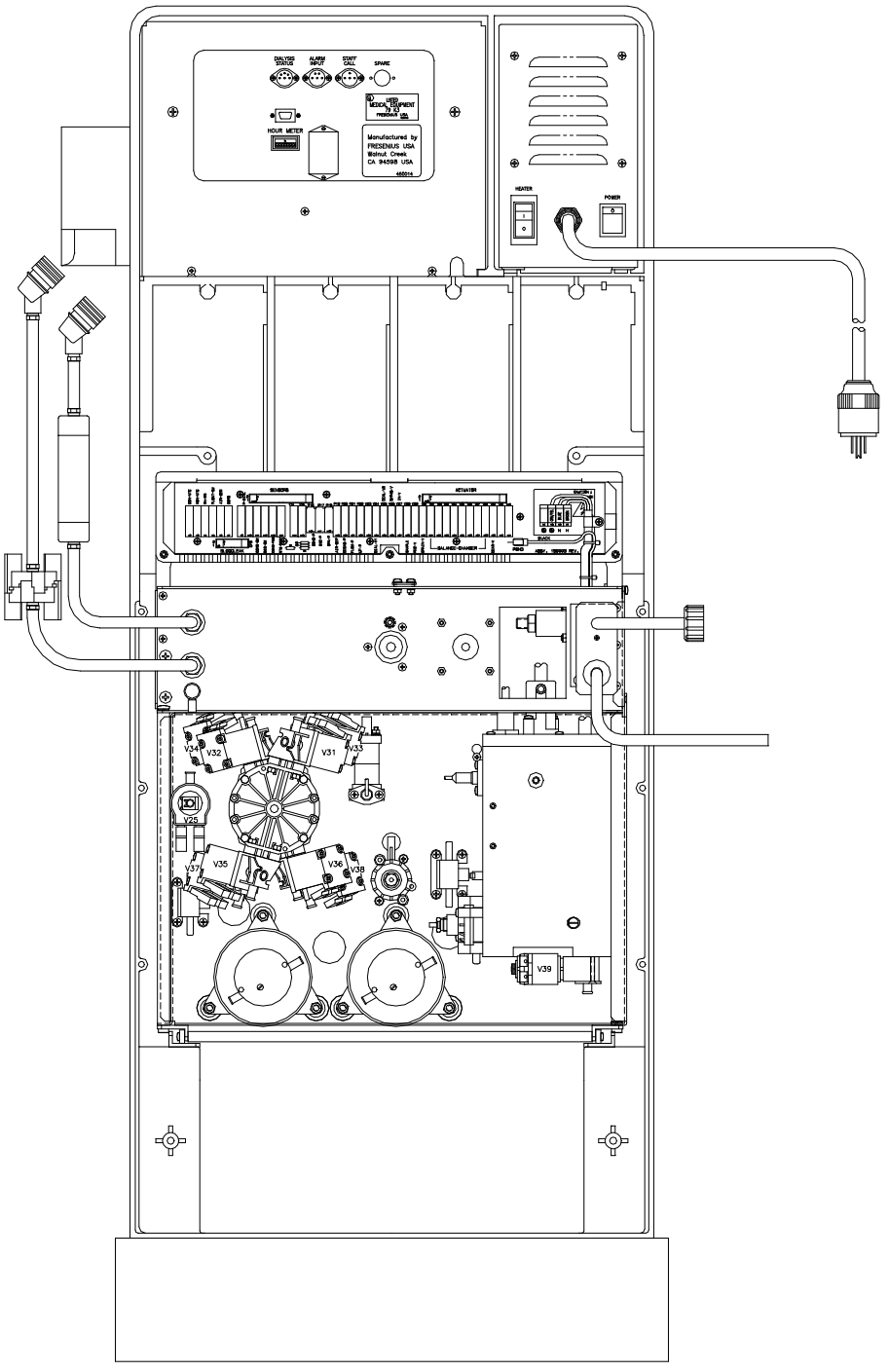
1 Bar	29.53 inHg
1 inHg	25.4 mmHg
1 Psi	51.72 mmHg

VOLUME

1 FLUID OUNCE	26.6 MILLILITERS
1 U.S QUART	0.946 LITERS
1 U.S. GALLON	3.8 LITERS
0.034 FLUID OUNCES	1 MILLILITER
1.057 QUARTS	1 LITER
0.26 U.S. GALLON	1 LITER

MASS

1 OUNCE (avdp.)	28.35 GRAMS
1 POUND (avdp.)	0.45 KILOGRAM
0.035 OUNCE (avdp.)	1 GRAM



FRESENIUS USA, INC.
2637 SHADELANDS Drive
Walnut Creek, CA 94598
800 227-2572

S E C T I O N V I I

TROUBLESHOOTING

DEBUG SCREENS

SCREEN 0: ACID/BICARB PUMPS

ACID = The current number of acid pump steps (per stroke) sent to the actuator board from the functional board (200 steps = 360 degrees). This value is determined by the currently selected concentrate and should make the acid pump deliver APV (see below).

BIC = The current number of bicarb steps (per stroke) sent to the actuator board from the functional board (200 steps = 360 degrees). This value is determined by the currently selected concentrate and should make the bicarb pump deliver BPV (see below).

A160 = Stroke volume of the acid pump at 160 steps per stroke. This value was determined and put into battery RAM during acid pump volume calibrations. (For example 8620 = 0.8620 ml/stroke).

A220 = Stroke volume of the acid pump at 220 steps per stroke. This value was determined and put into battery RAM during acid pump volume calibrations.

APV = Current acid pump stroke volume based on ACID = (For example 8620 = 0.8620 ml/stroke).

AACI = Actual value of acid steps sent to the acid pump by the actuator board. This value should equal ACID from above. The actuator board is able to determine AACI by monitoring the end of stroke (EOS) sensors on the acid pump. If AACI and ACID are not equal EOS errors will be present. See also debug screen 7, NO EOS or ALWEOS for further information.

ABIC = Actual value of bicarb steps sent to the bicarb pump by the actuator board. This value should equal BIC from above. The actuator board is able to determine ABIC = by monitoring the end of stroke (EOS) sensors on the bicarb pump. If ABIC and BIC are not equal EOS errors will be present. See also debug screen 7, NO EOS or ALWEOS for further information.

B160 = Current stroke volume (per stroke) of the bicarb pump at 160 steps per stroke. This value was determined and put into battery RAM during bicarb pump volume calibrations. (For example 8620 = .8620 ml/stroke).

B220 = Current stroke volume (per stroke) of the bicarb pump at 220 steps per stroke. This value was determined and put into battery RAM during bicarb pump volume calibrations.

BPV = Current bicarb pump stroke volume based on BIC = (For example 10534 = 1.0534 ml/stroke).

SCREEN 1: INPUTS (A)

These are functional board input pins used to monitor various machine functions. 1 = Yes (high), 0 = No (low). ! = no. For example !AIR reads "No Air?". The number inside the brackets are pin numbers on the 21 mother board connector unless otherwise specified.

UFPULS = UF pulse? This pin monitors the UF pump. Goes from 0 to 1 as the UF pump strokes. Also, if the UF pump solenoid goes to a high resistance state this pin goes high (=1) constantly causing the functional board to issue a UF PUMP ALARM. [A29]

LINOFF = Lines off? This pin = 1 if both the red and blue dialysate connectors are out of the shunt. Both dialysate lines must be in the shunt (LINOFF= 0) to start the cleaning modes. [A30]

!EMPTY = No empty? This pin = 0 if the red dialysate line is out of the shunt and the blue dialysate line is in the shunt. This configuration enables the "emptying program" causing all spent side balancing chamber valves to open, all fresh side balancing chamber valves to close while the flow pump runs. This "empties" the dialyzer of dialysate. [A31]

FLWOUT = This pin is directly from balancing chamber valve 33 and toggles from 1 to 0 as the balancing chamber valves cycle. 1 = valve 33 open. [C1]

FLWSTP = Flow stopped? This pin = 1 when flow stops for any reason. All balancing chamber valves are off during flow stop. [C2]

SERVSW = Service switch? In non-service mode = 0. NOTE: The service switch is located on the back panel.

BICOUT = Bicarb connector out? Bicarb connector not plugged into machine = 1 (reed switch K12 in the "open" state). [A3]

!AIR = No air? Air sensed in air removal chamber 69 = 0. [A7]

!BLOOD = No blood? Blood sensed by optical detector = 0. [C23]

CVRCLS = Shunt door closed? Shunt door closed = 1 [C6]

DIAVLO = Dialyze valve 24 open? Valve 24 open = 1 i.e. machine is not in bypass. This pin must = 0 if a bypass alarm becomes present. [C7]

ACIOUT = Acid connector out? Acid connector not plugged into machine = 1 (reed switch K11 in the "open" state). [A21]

SCREEN 2: INPUTS (B)

These are functional board input pins used to monitor various machine functions. 1 = Yes (high), 0 = No (low). ! no. For example !LD AL reads "No Level Detector Alarm?". The number inside the brackets are pin numbers on the P1 mother board connector unless otherwise specified.

LD UP = Level detector switch up? Venous chamber level adjust switch held up = 1. [C4] The level adjust switch is used to raise the level in the venous drip chamber.

LD DWN = This pin always = 0 (unused). [C5]

SW PNL = This pin always = 1. [A8]

!SWITCH = Power button not pushed? Pushed = 0. [A9]

TRIAC = If the triac is on this pin = 0 . [A10] In the first 10 seconds, after entering dialysis mode, the heater relay (RL3) is turned off so that no voltage is available to the triac while the temperature control circuit, on the sensor board, is fully on. This pin should be = 1 since there is no voltage available to the triac. If this pin goes low (TRIAC = 0) during this time a "HEAT RELAY TEST FAIL" will be issued by the functional board.

!EXTAL = Unused

!HEPAL = No heparin pump alarm? [C25]

!SNGNE = Single needle (venous) blood pump not running? Venous blood pump running = 0. [C26] During single needle operation, when the arterial blood pump runs, the venous blood pump does not and visa versa. This pin monitors the blood pump during so that the functional board can control the venous clamp. When the arterial blood pump runs, in single needle operation, the venous clamp is closed.

!BPSTP = No blood pump(s) stopped alarm? Blood pump (arterial or venous) stopped alarm = 0 (low). [C27] If the blood pump(s) are turned on this pin will = 0 15 or 30 seconds (adjustable on the LP340 board) after the blood pump(s) stop for any reason.

VEN BP = Optional venous (single needle) blood pump present? Pump present = 1. This pin must = 1 in order to turn single needle function on. [C28]

!LD AL = No level detector alarm? No level detector alarm = 1. [C24]

V12 OK = +12 vdc ok? The power logic board constantly monitors the +12 vdc power supply and informs the functional board of it's state via this pin [motherboard P2 connector, pin A21]. 12 ± 0.3 vdc = OK. If voltage is outside this range the functional board will issue a 12 volt high or low alarm.

SCREEN 3: OUTPUTS (A)

These are functional board output pins that issue commands to make various machine functions occur. 1 = Yes (high), 0 = No (low), ! = no. For example !FLOW reads “No Flow?”. The number inside the brackets are pin numbers on the P1 motherboard connector unless otherwise specified.

VNTVLO = Vent valve open? Open vent valve in self prime = 1. [C15] The vent valve is located inside the level detector module and vents the venous drip chamber to atmosphere when open. This pin does not go high when manually raising the venous level.

CLAMPO = Venous blood line clamp open? Open clamp = 1. [C16]

CLR AL = Clear alarms? Reset alarms to modules = 1. NOTE: This occurs too quickly to be seen in DEBUG. [C17]

!BPSTP = No blood pump stopped? Stop blood pump(s) = 0. [C18]

BPSPEC = Blood pump special? Special blood pump control = 1. [C19] This pin inputs the blood pump module and controls the blood pump to a maximum speed of 150ml/min. This occurs whenever the venous level switch is held up to raise the venous drip chamber level.

RINSE = In rinse? In rinse program = 1. [A22]

!FLOW = No flow? Flow off = 1 with a no water alarm. [A23]

!RELPR = No release pressure? Release dialysate pressure = 0. [A24]. This occurs when resetting a TMP alarm. This pin is not connected.

!DIAAL = No dialysate alarms? Dialysate alarms = Conductivity or temperature alarm or shunt door open = Machine in bypass = 0 i.e. valve 24 closed, valve 26 open. [A25] NOTE: This pin is not connected.

!FILL = No fill? Not in fill program = 1. [A26]. NOTE: This pin is not connected.

UFPULS = UF pump pulsed? Stroke UF pump = 1. [A27] The functional board strokes the UF pump during pressure holding tests.

SCREEN 4: OUTPUTS (B)

These are functional board output pins that issue commands to make various machine functions occur. 1 = Yes (high), 0 = No (low), ! = no. For example !DISHE reads “No Heat Disinfect”. The number inside the brackets are pin numbers on the P1 motherboard connector unless otherwise specified.

SNG NE = Single needle? Turn single needle on = 1. [C20]

!CNDRE = No conductivity resistor? Normally = 1. [A6] During conductivity cell calibrations the functional board takes this pin low (!CNDRE= 0) and turns on sensor board relay (RL2). This puts a fixed resistor (R6) into the sensor board conductivity counting circuit.

!CNDCA = No conductivity calibration? Normally = 1. [A5] During conductivity cell calibrations the functional board takes this pin low (!CNDCA = 0) and turns on sensor board relay (RL1). This removes the conductivity cell from the conductivity counting circuit.

HEAT = Heat relay on? On = 1. [A15] The heater relay (RL3), located in the upper power supply on the power control board, supplies 120 vac to the triac. The functional board keeps RL3 on as long temperature remains below 41.5°C in dialyze mode or 90°C in heat.

TRIWDR = Triac watchdog reset? (normally = 0). [A18] During power up the functional board tests the heater relay (RL3), located in the upper power supply on the power control board, for proper function. Reset = 1.

!DISHE = No heat disinfect? Machine in heat disinfect = 0. [C14] Generates high temperature for heat disinfect.

WARNSO = Warning sound on? On = 1. [A14]

ALM SO = Alarm sound on? On = 1. [A13]

NURSEC = Nurse call on? On = 1. [A16]

TRLGRE = Green traffic light on? Green traffic light on = 1. The so called traffic lights are optional and hang on the IV pole. Since they hang on the IV pole they can be seen from across the unit.

TRLYEL = Yellow traffic light on? Yellow traffic light on = 1.

TRLRED = Red traffic light on? Red traffic light on = 1.

SCREEN 5: ACTUATOR ERRORS

These are hardware alarm limit violations as generated by the actuator board. 1 = alarm. 0 = no alarm.

HITEMP = High temperature alarm.
LOTEMP = Low temperature alarm.
HICOND = High conductivity alarm.
LOCOND = Low conductivity alarm.
GRPERR = Not used.
BICERR = Bicarbonate pump error.
!WATER = No water alarm. Float has remained down for 5 seconds in dialyze mode, 10 seconds in cleaning modes.
FLWERR = Flow error. All flow problems other than no water.
ACEERR = Acetate pump error.
SENERR = Sending error. Not used.
UFPERR = UF pump error. Not used.
VLVERR = Valve error. Normally = 0. Pulses to 1 about every 60 seconds if a valve coil is sensed "open" by one of the actuator smart drivers ("open" = no coil current).

SCREEN 6: ART/VEN/TMP

HI ART = Hardware high arterial alarm (actuator).
LO ART = Hardware low arterial alarm (actuator).
HI VEN = Hardware high venous alarm (actuator).
LO VEN = Hardware low venous alarm (actuator).
HI TMP = Hardware high TMP alarm (actuator).
LO TMP = Hardware low TMP alarm (actuator).
AART = Calculated arterial pressure by actuator board to within 1 mmHg.
AVEN = Calculated venous pressure by actuator board to within 1 mmHg.
ATMP = Calculated TMP by actuator board to within 1 mmHg.
ART = Functional board precise arterial pressure to within 1 mmHg.
VEN = Functional board precise venous pressure to within 1 mmHg.
TMP = Functional board precise TMP to within 1 mmHg.

SCREEN 7: MISCELLANEOUS (A)

Actuator board values. 1 = Yes, 0 = No

BYVERR = Unused

BYPASS = Bypass active i.e. conductivity or temperature alarm.

FILACT = Fill program active.

DOUBLE = Bicarb pump double stroke. NOTE: The bicarb pump does not necessarily double stroke as it does on E and D model machines.

FLWOFF = Flow is off. [motherboard input pin C2]

FLVERR = Unused.

NO EOS = No EOS (end of stroke) from the acid or bicarb pump. NOTE: Each concentrate pump has two optical sensors (called EOS sensors). These sensors monitor the concentrate pumps allowing the actuator board the ability to determine the number of steps used by the pumps. The number of steps sent to the pump should equal the number of steps used by the pump i.e. ACID = AACI or BIC = ABIC. If there is a discrepancy between steps sent and steps used an EOS error will be issued by the actuator board. NO EOS means that the pump has not sent an EOS signal to the actuator board in spite of the actuator board sending up to 500 steps to the pump. See also debug screen 0, AACI or ABIC.

ALWEOS = Always EOS (end of stroke) from the acid or bicarb pump. NOTE: Each concentrate pump has two optical sensors (called EOS sensors). These sensors monitor the concentrate pumps allowing the actuator board the ability to determine the number of steps used by the pumps. The number of steps sent to the pump should equal the number of steps used by the pump i.e. ACID = AACI or BIC = ABIC. If there is a discrepancy between steps sent and steps used an EOS error will be issued by the actuator board. ALWEOS means that the pump has sent an EOS signal with only about 100 steps sent to the pump. An EOS should not be occurring this quickly. See also debug screen 0, AACI or ABIC.

FILSTA = Fill program has started.

ACTBLD = Blood sensed in the optical detector by the actuator board. [motherboard input pin A4]

0TMP = Raw TMP value without taking blood or dialysate flow into account.

BFLW = Current blood flow rate in ml/min.

SCREEN 8: ACTUATOR DEBUG

These 12 values may mean anything and will vary between different versions of actuator board software. They are used for arbitrary debugging.

SCREEN 9: A-TO-D

Sensor board input A-TO-D values in volts dc. Numbers in brackets are sensor board input pins. Numbers in parenthesis are sensor board ADC inputs. x2 is the ribbon cable connector that plugs into the top of the sensor board. This cable runs to the distribution board. For example x2/6 reads connector x2, pin 6

LEAK =	Blood leak receiver (ADC channel 0). [x2/6]
DIMN =	Blood leak dimness receiver (ADC channel 1). [x2/7]
PART =	Arterial pressure (ADC channel 2). [A27]
PVEN =	Venous pressure (ADC channel 3). [A32]
PDIA =	Dialysate pressure (ADC channel 4). [x2/8, x2/10]
TEMP =	Temperature monitor NTC3 (ADC channel 5). [x2/12]
ABPR =	Arterial blood pump rate (ADC channel 6). [A28]
VBPR =	Venous (single needle) blood pump rate (ADC channel 7). [A29]
5V =	5v power supply (ADC channel 8). [C31]
24V =	24v power supply (ADC channel 9). [C30]
ASET =	Arterial blood pump set (ADC channel 10). [A12]
VSET =	Venous blood pump set (ADC channel 11). [A11]

SCREEN 10: CLOCK, A-TO-D

Sensor board input A-TO-D values in volts dc. Numbers in brackets are sensor board input pins. Numbers in parenthesis are ADC input channels. x2 is the ribbon cable connector that plugs into the top of the sensor board. This cable runs to the distribution board. For example x2/14 reads connector x2, pin 14

UN12 =	Unused
CFS =	Chamber full switch 10 (ADC channel 13). [x2/14, x2/15]
UN14 =	Unused
HEAT =	Temperature monitor NTC3 for heat disinfect (ADC channel 15). [x2/12]
SECOND =	Real time seconds.
MINUTE =	Real time minutes.
HOUR =	Real time hours.
DATE =	Real time date.
MONTH =	Real time month.
YEAR =	Real time year.

SCREEN 11: ACTUATOR A-TO-D

Actuator board input A-TO-D values in volts dc. Numbers in brackets are actuator board input pins. Numbers in parenthesis are actuator board ADC input channels).

ACFS = Actuator CFS value (ADC channel 0). [C19]
ADIA = Actuator dialysate pressure (ADC channel 1). [A17]
AART = Actuator arterial pressure (ADC channel 2). [C17]
AVEN = Actuator venous pressure (ADC channel 3). [C18]
ATEM = Actuator temperature display (ADC channel 4). [A18]
ABLD = Actuator blood leak sensor (ADC channel 5). [A19]
A12V = Actuator +12 v power supply (ADC channel 6). [C24]
A24V = Actuator +24 v power supply (ADC channel 7). [C29]
XTRM = Last byte received from transterm.
CMS =

SCREEN 12: COMMUNICATION

Functional board communication data. Used in software development.

XTMI =
XTMO =
BPMI =
BPMO =
FDSI =
FDSO =
FDS# =
FDSX =
FDSR =
00F2 =
00F4 =
00F6 =

SCREEN 13: INTERRUPTS

Functional board MPU interrupts. Used in software development.

I0 =
I3 =
I6 =
I9 =
IC =
IF =

SCREEN 14: PARAMETER RAM

This and the next three screens show a series of values in RAM. The addresses shown can be scrolled through using the left and right arrow keypads. Each hex value display is a 4-digit word; the first two digits make up the byte at the address listed, and the next two digits are the byte at the address plus 1. 68302 parameter RAM is memory used for hardware communication registers. Variable RAM holds the functional board software's variables and varies from version to version. Battery RAM holds calibration and dialysis parameter values.

SCREEN 15: VARIABLE RAM

SCREEN 16: BATTERY RAM

SCREEN 17: MISCELLANEOUS (B)

Miscellaneous actuator board values.

FLWP =	255 minus this value = DAC value sent to flow pump from actuator board.
DEAP =	255 minus this value minus = DAC value sent to deaeration pump from actuator board.
TEMP =	Calculated temperature.
5V =	Precise 5 v reading based on 12 v power supply.
12V =	Precise 12 v reading.
SALV =	
PHTACT =	On-line pressure holding tests active.
NPHT =	Seconds until next on-line pressure holding test.
PHT0 =	Result of PHT first valve combination.
PHT1 =	Result of PHT second valve combination.
BPCE =	

SCREEN 18: SELF-TEST

RAWT =
GOTT =
TSTT =
CURT =
MODE# =
DOING =
TIME =
DELAY =
FAIL# =

SCREEN 19: CONDUCTIVITY

COND = Current conductivity cell (7) frequency. This value is independent of conductivity calibrations.

BCV = Balancing chamber volume from calibration data. (For example 600 = 60.0 ml.)

ACON = Calculated, current, actuator board conductivity value.

CELL = Conductivity cell frequency. (Sensor board relay 1 and relay 2 off). **Approximately 1800 to 1900 Hertz.** This value is determined and put into battery RAM, along with CREF and COFS, during conductivity cell calibrations.

CREF = High end conductivity reference frequency. (Sensor board relays 1 and 2 are on. The conductivity circuit reads R6 = 17 mS). **Approximately 2750 to 2850 Hertz.** This value is determined and put into battery RAM, along with CELL and COFS, during conductivity cell calibrations.

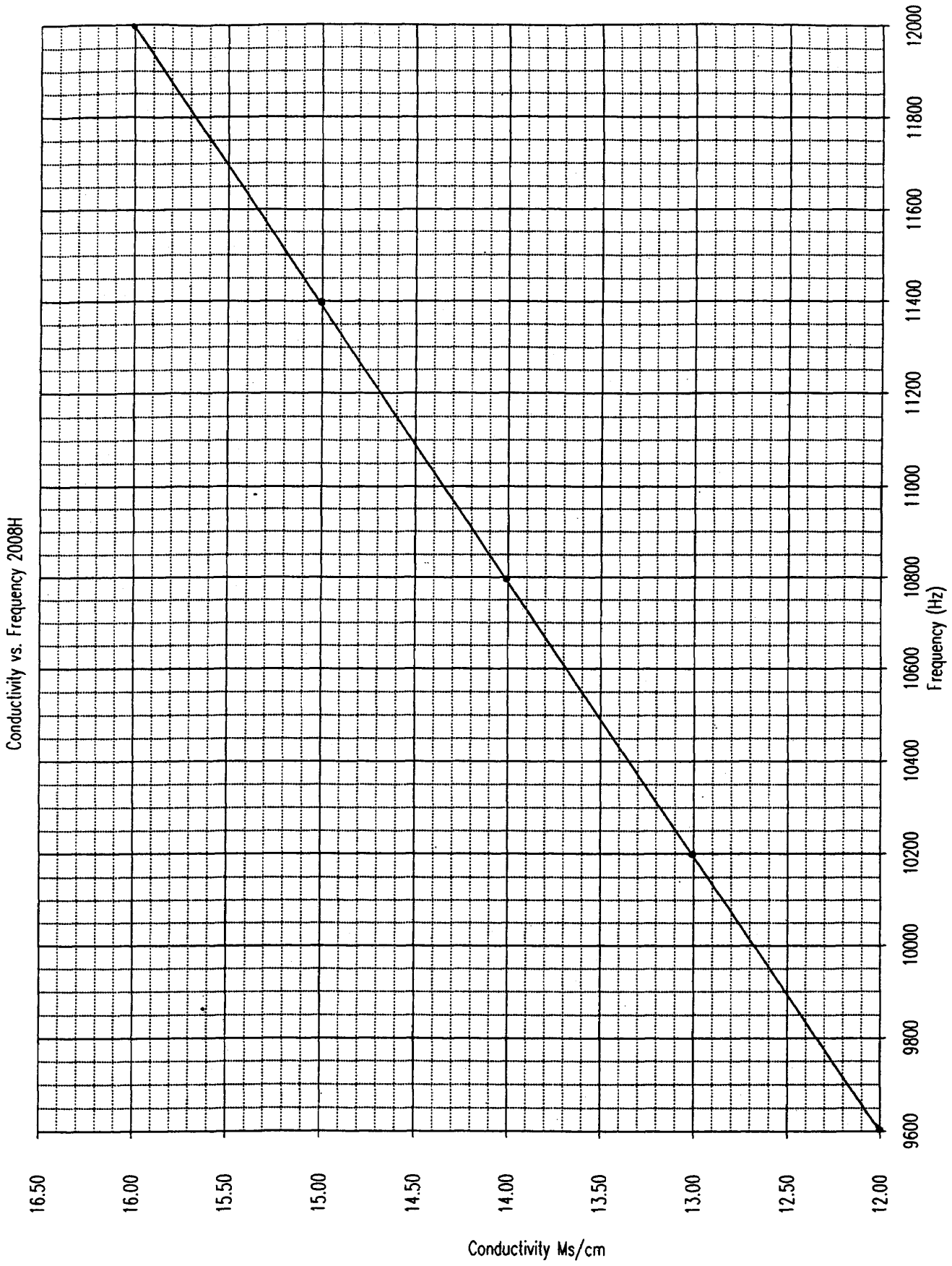
COFS = Low end conductivity reference frequency. (Sensor board relay 1 on, relay 2 off. The conductivity circuit reads high resistance). **Approximately 580 to 600 Hertz.** This value is determined along with CELL and CREF during conductivity cell calibrations.

!ECH =
!ACK =
!SUM =

SCREEN 20: ACTUATOR VALVES

These are signals sent to valve latches by the actuator board MPU. Valve open = 1, valve closed = 0.

V24=	V31=	V37=
V25=	V32=	V38=
V26=	V33=	V39=
V28=	V34=	V41=
V29=	V35=	V42=
V30=	V36=	V43=


Conductivity vs. Frequency 2008H
Conductivity Ms/cm
16.50
16.00
15.50
15.00
14.50
14.00
13.50
13.00
12.50
12.00
Frequency (Hz)
9600
9800
10000
10200
10400
10600
10800
11000
11200
11400
11600
11800
12000

ALARMS AND WARNINGS

Standard alarm results: alarm sound muting is cleared, and the alarm sound starts. A message is displayed on the top line of the screen, indicating the alarm. Note that the message may be hidden by a more important alarm message (see 9.A). The Alarm LED lights up.

Standard blood alarm results: standard alarm results, plus: if there is an appropriate LED, it is lit, and if this is the first blood alarm, it flashes. The blood pump is stopped, except in special situations. Blood leak overriding is stopped. If this isn't a TMP alarm, the TMP limits are spread. UF is interrupted.

Standard alarm removal: press the Reset key. Of course if the alarm condition is still true, it may immediately recur.

Fatal alarms: these alarms kill the watchdog, thus turning off 24 volts. Hardware pins are set to a safe state, a message is displayed, and the microprocessor is turned off. The user must turn the machine off and back on to clear one of these alarms.

Assume the above standards in the individual alarm descriptions, except where specifically contradicted.

A. Blood Alarms

ALARM: Arterial/Venous Pressure Hard Limit Alarm (low/high)
CAUSE: Either the a-to-d value is <= 11 or >= 210 (the LED is thus at one end of the scale) or the Actuator board has signaled this alarm.
MESSAGE: None.

ALARM: Arterial/Venous Pressure Soft Limit Alarm (low/high)
CAUSE: The LED has been 1 LED out of limits for 8 seconds, or 8 LED's out of limits for 1 second, or some proportional amount (e.g. 2 LEDS out of limits for 4 seconds). 1 LED out means touching the limit LED. This test will be overridden for 10 seconds by the following:

1. Entering dialysis.
2. Overriding a blood leak.
3. Pressing the chamber adjust switch up or releasing it.
4. Clearing any blood alarm or a permanent filling alarm.
5. Having a blood pump stop alarm clear itself.
6. When performing the arterial/venous hard limit test.

MESSAGE: None.

ALARM: TMP Hard Limit Alarm (low/high)
CAUSE: The user is not adjusting TMP, and either the LED is at one end of the scale, or else the Actuator board has signaled this alarm.
MESSAGE: "TMP IS LOW" or "TMP IS HIGH".

ALARM: TMP Soft Limit Alarm (low/high)

CAUSE: The TMP value is out of limits. This test will be overridden for 10 seconds by the following:

1. Overriding a blood leak.
2. Pressing the chamber adjust switch up or releasing it.
3. Clearing any blood alarm or a permanent filling alarm.
4. Having a blood pump stop alarm clear itself.

Also, on some occasions where one or both of the TMP limits are spread, the soft limit alarms are overridden for 10 seconds.

MESSAGE: "TMP IS LOW" or "TMP IS HIGH".

ALARM: Level Detector Alarm

CAUSE: The NO-LEVEL-DETECTOR-ALARM pin is low, and the machine is not in prime.

MESSAGE: "AIR DETECTOR ALARM".

ALARM: Blood Leak Alarm

CAUSE: caused by the value from the BLOOD-LEAK channel being below a threshold, which is determined by the flow rate.

REMOVAL: Note that this alarm can be temporarily (3 minutes) overridden, such that the blood pump runs and no alarm sound is made, by pressing the Override key.

MESSAGE: "BLOOD LEAK?".

ALARM: Blood Leak Calibration Alarm

CAUSE: After having been in dialysis for at least 1 minute, the following conditions must be true for 10 seconds : the BLOOD-LEAK channel is greater than 123 (about 5.7 volts) and the AIR-NOT-SENSED pin is high (to try to prevent false failures which occur when air is sensed), and BLOOD IS NOT SENSED.

RESULT: A blood alarm, except that TMP limits are not spread.

MESSAGE: "BLOOD LEAK NOT CALIB".

ALARM: Blood Pump Feedback Alarm

CAUSE: For 45 seconds, the blood pump has been on, and either: the ART-KNOB value has been less than 2 volts (42 units), with the ART-DELIVERY value differing from ART-KNOB by at least 1 volt (22 units); or, the ART-KNOB value has been at least 2 volts, and the ART-DELIVERY value has been less than 1 volt.

MESSAGE: "BP FEEDBACK ERROR".

ALARM: Blood Pump Stop Alarm

CAUSE: The NO-BLOOD-PUMP-STOP-ALARM pin has gone low. This alarm will occur after the pump has been stopped for 30 seconds; this will thus happen 30 seconds after any other blood alarm.

MESSAGE: "BLOOD PUMP STOPPED".

B. Other Alarms

ALARM:	External Alarm
CAUSE:	The NO-EXTERNAL-ALARM pin is low.
MESSAGE:	“EXTERNAL ALARM”.

ALARM:	Conductivity Alarm (low/high)
CAUSE:	If the FLOW-STOP-ACKNOWLEDGE pin is low, or the flow rate is not Sequential, then these alarms are generated by either the conductivity value (displayed on the dialysis screen) being out of limits (displayed on the conductivity screen), or by the actuator board reporting this alarm.
RESULT:	The machine goes into bypass.
MESSAGE:	“CONDUCTIVITY LOW” or “CONDUCTIVITY HIGH”.

ALARM:	Temperature Alarm (low/high)
CAUSE:	The temperature value is out of limits, or the actuator board has reported the alarm. The low temperature alarm can only happen if FILL-OFF is high, and either FLOW-STOP-ACKNOWLEDGE is low, or the flow rate is not Sequential.
RESULT:	The machine goes into bypass. If a high temperature alarm occurs with the temperature above 41.0°C, the temperature set point is set to 0.
MESSAGE:	“LOW TEMPERATURE” or “HIGH TEMPERATURE”.

ALARM:	UF Pump Alarm
CAUSE:	10 times, since the machine has been turned on, one of the following things has occurred: 1. The UF-PULSED-HI pin has been high when not expected. 2. The UF-PULSED-HI pin has been low 150ms after generating a pulse with UF-PULSE-HI. 3. The UF-PULSED-HI pin has been high 350ms after generating a pulse with UF-PULSE-HI.
RESULT:	UF is interrupted.
MESSAGE:	“UF PUMP FAILED”.

ALARM:	Heparin Pump Alarm
CAUSE:	The NO-HEPARIN-ALARM pin is low.
MESSAGE:	“HEPARIN PUMP FAILURE”.

ALARM:	Permanent Filling Program Alarm
CAUSE:	A filling program has lasted one minute with blood sensed.
RESULT:	Flow is turned off. The machine goes into bypass. UF is interrupted. The blood pump is stopped.
MESSAGE:	“FILL PROGRAM ALARM”.

C. Warnings

WARNING:	Blood Leak Warning
CAUSE:	Caused by the value from the BLOOD-LEAK channel being below a threshold, which is determined by the flow rate.
MESSAGE:	“BLOOD LEAK?”.

WARNING:	Flow Error Warning
CAUSE:	The actuator board generates this alarm, due to one of several possible errors.
RESULT:	The heater relay is turned off.
MESSAGE:	“FLOW ERROR”, “FLOW RECIRC ERROR”, “FLOW INLET ERROR”, “LOW FLOW ERROR”, “HIGH FLOW ERROR”.

WARNING:	No Water Warning
CAUSE:	The actuator board generates this alarm.
RESULT:	The heater relay is turned off.
MESSAGE:	“NO WATER”.

WARNING:	Ten Filling Programs Warning
CAUSE:	Ten filling programs have happened during one hour, with blood sensed.
MESSAGE:	“10 FILL PGM IN 1 HR”.

WARNING:	Pump Failure Warning
CAUSE:	One of six conditions indicated by the actuator board. This warning is overridden for 20 seconds after the desired state of the dialysis valve changes.
MESSAGE:	“ACID PUMP ALWAYS EOS”, “ACID PUMP FAILURE”, “ACID PUMP NO EQS”, “BIC PUMP ALWAYS EOS”, “BIC PUMP FAILURE”, or “BIC PUMP NO EOS”.

WARNING:	UF Goal Warning
CAUSE:	The UF removed, after being incremented due to a UF pulse, is equal to the UF goal.
RESULT:	UF time is reset to 0. The lower TMP limit is spread, and TMP soft alarms are prevented for 10 seconds. The UF pump runs at minimum rate of 70 ml/hr.
MESSAGE:	“UF GOAL REACHED”.

WARNING:	Emptying Stopped Warning
CAUSE:	An emptying program has ended. This is determined when air is sensed (AIR-NOT-SENSED low) with the NOT-EMPTYING pin low, and no filling program in progress.
RESULT:	The machine is in bypass. UF is interrupted.
MESSAGE:	“EMPTYING STOPPED”.

WARNING:	Flow Off Air Warning
CAUSE:	Flow is off (FLOW-STOP-ACKNOWLEDGE is high) with air sensed (AIR-NOT-SENSED is low) with Sequential flow rate selected, for 30 UF strokes (i.e., until the volume in the balancing chamber is 30 ml).
RESULT:	UF is interrupted.
MESSAGE:	“AIR IN SYSTEM ?“

WARNING:	Shunt Cover Warning
CAUSE:	The shunt cover is open (SHUNT-COVER-CLOSED is low).
RESULT:	The machine is in bypass.
MESSAGE:	“** COVER IS OPEN **”

WARNING:	Maximum UF Rate Warning
CAUSE:	The user has tried to select a UF rate that is higher than the maximum allowed, as defined by the dipswitches.
RESULT:	UF is interrupted.
MESSAGE:	“MAXIMUM UFR REACHED”.

WARNING:	Flow Off Warning
CAUSE:	Flow has been off (FLOW-STOP-ACKNOWLEDGE high) for either 60 minutes of Sequential or 10 minutes of 300-800 flow rate.
MESSAGE:	“10 MINUTES FLOW OFF”, “60 MINUTES FLOW OFF”.

WARNING:	RTD Warning
CAUSE:	Remaining Time of Dialysis has counted down to 0.
RESULT:	Note that the sound this warning produces is unaffected by dipswitch 4.
MESSAGE:	“RTD = ZERO”.

WARNING:	Dialyzer Warning
CAUSE:	Blood is sensed (BLOOD-NOT-SENSED pin low) with the blood pump knob above the minimum value allowed for UF (ART-KNOB channel > 30, about 90 ml/min), and the tubes are on the shunt (DIALINE-OFF-SHUNT is low).
MESSAGE:	“DIALYZER CONNECT ?“.

WARNING:	Test Complete Warning
CAUSE:	This warning occurs when the test is finished.
MESSAGE:	“TEST COMPLETE”.

D. Fatal Alarms

ALARM:	Watchdog Test Failed
CAUSE:	The power-up watchdog test has failed. The appropriate message depends on the test step failed.
MESSAGE:	"*** 24V HIGH ***", "*** 24V LOW ***", "WD: 24V RECOVER FAIL", "WD: FAIL EARLY PULSE", or "WD: FAIL LATE PULSE".

ALARM:	Conductivity Test Failed
CAUSE:	The calibrated values for conductivity reference and offset differed from values read from the hardware by more than 10 units. This is a power-up test.
MESSAGE:	"COND REF FAILURE" or "COND OFFSET FAILURE".

ALARM:	Battery RAM Failed
CAUSE:	A power-up test of the battery RAM indicated that it is not retaining values stored to it.
MESSAGE:	"* BAT RAM DOWN *"

ALARM:	Must Calibrate Machine
CAUSE:	Calibrations required for running a treatment have not been performed. This alarm does not occur in T&C mode.
MESSAGE:	"MUST CALIBRATE TO RUN".

ALARM:	Software Display Failure
CAUSE:	There are three conditions for which the software will detect that it is not able to display something correctly. If any of these three things happens, it indicates a software problem.
MESSAGE:	"STRING QUE FULL", "SCREEN QUE FULL", "SCRN NOT IN DISP RAM".

ALARM:	Blood Pump Failure
CAUSE:	The arterial blood pump has been off (BLOOD-PUMP-SPECIAL-CONTROL low and BLOOD-PUMP-SYSTEM-STOP-OFF low) with the ART-DELIVERY voltage above 0.5 volts (10 units) for 20 seconds.
MESSAGE:	"BLOOD PUMP FAILURE".

ALARM:	Dialysate Valve Failure
CAUSE:	This alarm happens if the detected state of the dialysis valve (via DIALYSIS-VALVE-OPEN) is not the correct state, for 20 seconds. This alarm is inhibited during the test, and during the actuator board pressure holding test. The correct state is open normally, and closed if the machine is in bypass, emptying, or adjusting TMP.
MESSAGE:	"DIAL VALVE FAILURE".

ALARM: Communication Failure
CAUSE: The functional board has failed 10 times to communicate correctly with the actuator board.
MESSAGE: “ACTUATOR BD NO ECHO”.

ALARM: Actuator Board CRC Failure
CAUSE: The actuator board has reported that the CRC on its EPROM is incorrect.
MESSAGE: “ACT BOARD CRC ERROR”.

ALARM: Actuator Board Blood Pump Failure
CAUSE: The actuator board has reported that the blood pump has failed (by running when it shouldn’t).
MESSAGE: “ACT BLOOD PUMP FAILED”.

ALARM: Actuator Board Bypass Valve Failure
CAUSE: The actuator board has reported that the bypass valve has failed (by being in the wrong state).
MESSAGE: “ACT BYP VALVE FAILED”.

ALARM: Interrupt Reentrance Alarm
CAUSE: The 50ms interrupt has reentered itself. This should never happen.
MESSAGE: “ERR 01 UNKNOWN CODE”.

ALARM: Maximum Temperature Alarm
CAUSE: The temperature during heat disinfect exceeds 95°C.
MESSAGE: “TEMP OVER 95 DEGREES”.

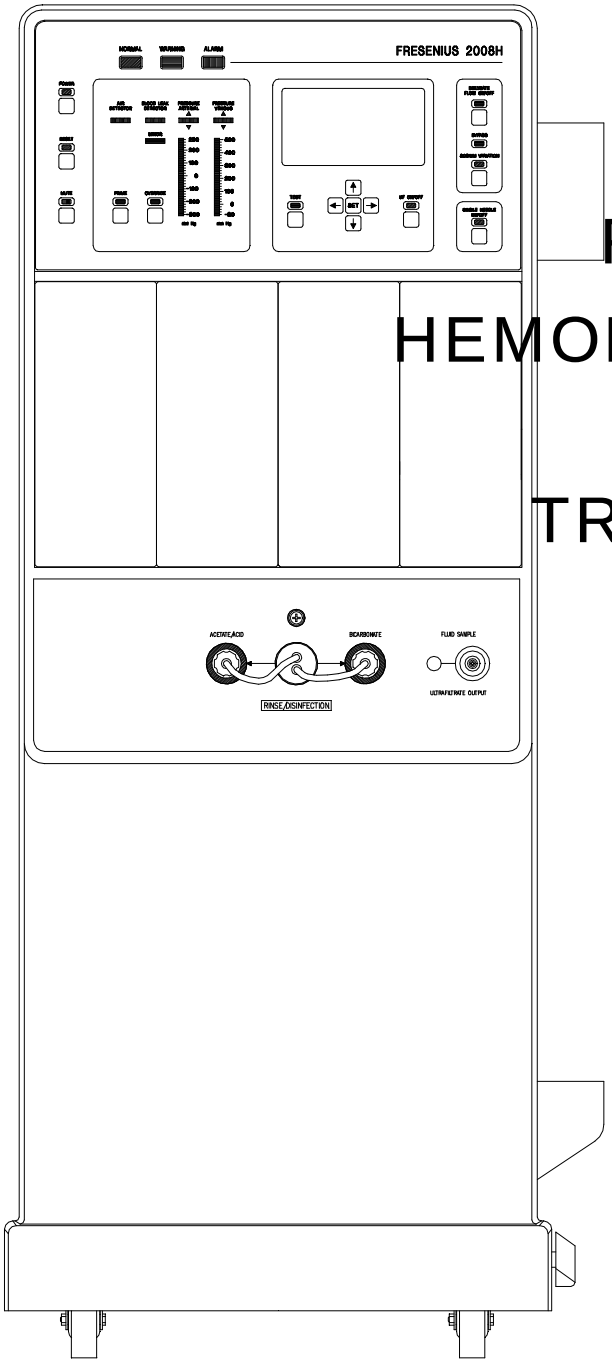
ALARM: Heater Relay Test Failed
CAUSE: The heater relay test failed.
MESSAGE: “HEAT RELAY TEST FAIL”.

ALARM: Power Failure
CAUSE: Power failures are detected for the 5 volt, 12 volt, and 24 volt supplies. The error conditions for each must be true for either 2 checks in dialysis or 20 checks in rinse, which will make it 1 second in either case before the alarm occurs. The error conditions are as follows:

5 volts	5-VOLTS	is <= 191 (4.5 volts)
		or >= 244 (5.74 volts).
12 volts	12-VOLTS-OK	is low.
24 volts	24-VOLTS	is <= 170 (20 volts)
		or >= 246 (28.9 volts).

MESSAGE: “*** 5V HIGH ***”, “**** 5V LOW ****”, “* 12V POWER FAIL *”, “*** 24V HIGH ***”, “*** 24V LOW ***”.

ALARM:	CRC Failure
CAUSE:	The power-up CRC test failed on the functional board, indicating one or more bad bytes in the EPROM.
MESSAGE:	“ * EPROM ERROR * “.



FRESENIUS 2008H HEMODIALYSIS SYSTEM

TROUBLESHOOTING GUIDE

Part Number 507082 Rev. B

FRESENIUS USA, INC.

2637 Shadelands Drive, Walnut Creek, CA 94598

800-227-2572 or 925-295-0200

TECHNICAL SUPPORT FOR HEMODIALYSIS SYSTEMS

Press 5 when the automated system answers.

AUTOMATED PHONE SYSTEM MENU

Press	To Reach
1	An individual 4-digit extension
5	Technical Support
6	Spare Parts Ordering
0	Operator

USEFUL EXTENSION AND FAX NUMBERS

Technical Support
Receptionist X7003 FAX 925-988-1969

Technical Training
Receptionist X7264 FAX 925-988-1969

Spare Parts
Receptionist X7004 FAX 925-988-1969

REGIONAL EQUIPMENT SPECIALIST: _____

FRESENIUS 2008H
HEMODIALYSIS SYSTEM

TROUBLESHOOTING
GUIDE

Part Number 507082 Rev B

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PREFACE

This troubleshooting guide has been developed with the help of many customers and Fresenius personnel. It is a combination of known techniques and excellent feedback from people that actually work with the equipment.

The intent of the 2008H Troubleshooting Guide is to provide you with an aid in the diagnosis of common problems. Since this document is only a guide and may not provide the most up-to-date solutions for every conceivable problem, we recommend contacting our Technical Services Support line should additional assistance be required.

WARNING: Before using this guide you must read pages 1 through 4 which outline Using the Troubleshooting Guide, Order of Troubleshooting, Initial Checks, Safety Checks and Equipment Needed. Never troubleshoot with a patient connected to the machine. If possible, remove the machine from the treatment area when it is being serviced. Always tag the machine to ensure it is not accidentally returned to service before the service work is completed.

Always fully test a machine (in accordance to the Technicians Manual P/N 490004 or Operators Manual P/N 490005) when maintenance and/or repairs have been completed. This is to include confirmation of conductivity, pH and Temperature with a calibrated device.

Should additional technical assistance be needed, technical support is provided 24 hours a day, seven days a week at our toll free number (800) 227-2572.

USING THE TROUBLESHOOTING GUIDE

1. The equipment technician should have knowledge of clinical Hemodialysis and operational theory of the Fresenius system. A minimum of Level I training is necessary! Incorrect troubleshooting can result in injury or death to the troubleshooter and patient.

2. The equipment technician should have knowledge of the test equipment, especially the multimeter. Refer to the meter's operational manual as necessary.

3. The troubleshooting procedures are written in 'flow chart' style that systematically eliminates possible areas of failure. Read each procedure carefully before moving on. You will be prompted to the next procedure or to possible solutions. Pay careful attention to **CAUTIONS** and **NOTES**.

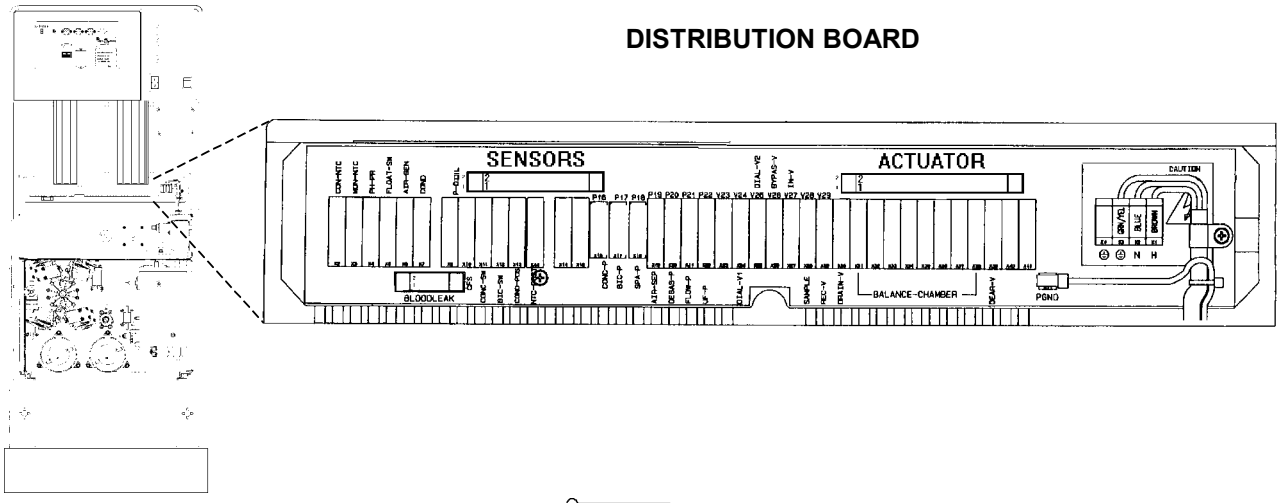
4. Many of the troubleshooting procedures are performed at the DISTRIBUTION BOARD.

   a) Inside the distribution board are several numerically identified 'male' connector positions. Male pins are arranged vertically and are numbered 1 through 5 (from top to bottom).

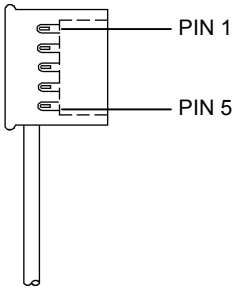
   b) Each hydraulic component has a 5-pin female connector dedicated to numeric distribution board positions as specified in the HYDRAULIC FLOW DIAGRAM. For example, flow pump #21 plugs into position [P21, FLOW-P]. Valve 43 plugs into position [V43], etc. Except for the heater, acid pump, and bicarb pump, you can plug and unplug connectors into the distribution board with the power on.

   NOTE: There are several unused positions including; x4 [PH-PR] (pH probe, optional), x13 [COND-POS] (on-line clearance, optional), x44 [NTC-POS] (on-line clearance, optional), V14, V15, x19 [AIR-SEP], V23 and x40 [V42]. Be CAREFUL not to accidentally plug a connector into one of these.

DISTRIBUTION BOARD



FEMALE CONNECTOR



5. If unsuccessful please call Technical Services at 1-800- 227- 2572.

THE 'ORDER' OF TROUBLESHOOTING

Troubleshoot in the following order:

1. No Water
2. Flow Errors
3. Temperature
4. Conductivity
5. TMP
6. Blood Leak
7. Pressure Holding Test Failures

NOTE: Before beginning we recommend that you perform INITIAL CHECKS (page 3). This is especially important if someone has been working on the machine before you!

1. NO WATER (debug screen 5, !WATER = "1" either constantly or intermittently). Without water hydraulic operation is not possible.

2. FLOW ERRORS (debug screen 5, FLWERR = "1" either constantly or intermittently), will effect Temperature, Conductivity, TMP and Blood Leak. If a FLOW ERROR is present troubleshoot it before being concerned with any other alarms.

3. FLOW ERRORS turn the heater off and result in TEMPERATURE problems. Before troubleshooting any TEMPERATURE problem assure that the machine is free of flow errors (debug screen 5, FLWERR = "0" constantly).

4. CONDUCTIVITY is temperature compensated. Without stable temperature CONDUCTIVITY will not be stable. Before troubleshooting CONDUCTIVITY problems, assure that TEMPERATURE is normal and remaining constant from the main dialysis screen.

5. Before troubleshooting TMP problems assure that there are no flow errors present (debug screen 5, FLWERR = "0" constantly). Assure also that TEMPERATURE and CONDUCTIVITY are normal and remaining constant from the main dialysis screen.

6. Before troubleshooting PRESSURE HOLDING TEST FAILURES assure that there are no flow errors present (debug screen 5, FLWERR = "0" constantly). Assure also that TEMPERATURE and CONDUCTIVITY are normal and remaining constant from the main dialysis screen.

7. Before troubleshooting BLOOD LEAK problems assure that there are no flow errors present (debug screen 5, FLWERR = "0" constantly). Assure also that TEMPERATURE and CONDUCTIVITY are normal and remaining constant from the main dialysis screen.

FUNCTIONAL BOARD SOFTWARE DISCLAIMER
Functional board software may effect the TROUBLESHOOTING GUIDE. With the exception of CONDUCTIVITY PROBLEMS this guide is compatible with functional software up to 8.02

INITIAL CHECKS

1. Turn the power **OFF** and slide the card cage forward. Check that all five boards are pushed down into the motherboard and are 'locked' in.

2. Check that the sensor and actuator cables are plugged tightly into *both ends. Check also for bare wires or other damage along their entire length.

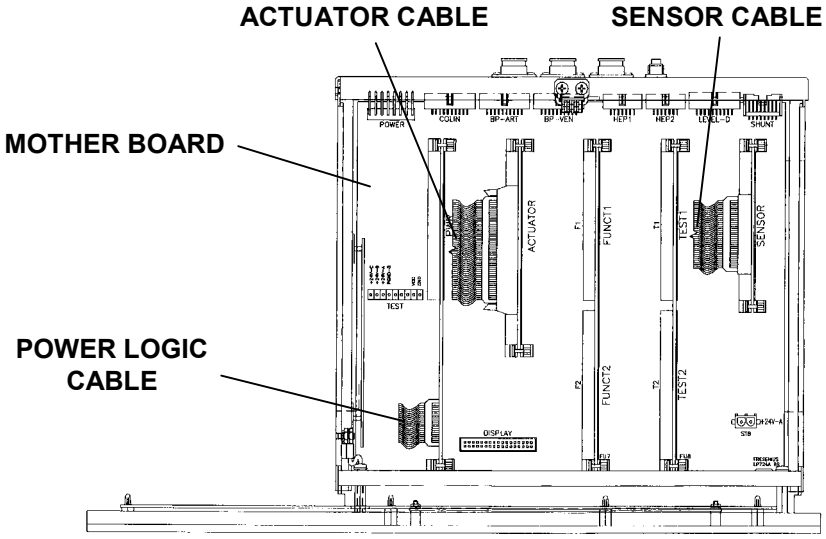
* Both cables run into the distribution board and terminate at the SENSORS and ACTUATOR connectors respectively (see DISTRIBUTION BOARD diagram below).

3. Check that the power logic board cable is plugged tightly into the power logic board.

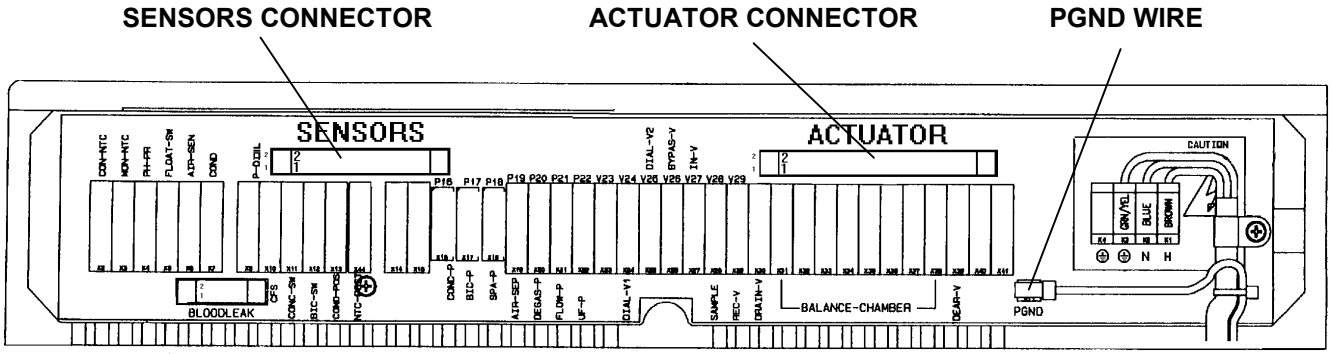
4. Check that the PGND (power ground) wire is plugged into the distribution board (see DISTRIBUTION BOARD diagram below).

5. Close the card cage**. IMPORTANT NOTE**! Do **NOT** troubleshoot with the card cage open! Turn the machine ON and return to the operating mode (DIALYSIS, RINSE, etc) where the problem is occurring.

6. Allow 10 minutes for stabilization.



CARD CAGE, TOP VIEW



DISTRIBUTION BOARD

SAFETY CHECKS

Before placing the machine back into service:

1. Remove all test equipment (jumpers, 'dummy' connectors, etc) from the distribution board and make sure that all hydraulic components are plugged in.

2. If you have been troubleshooting TEMPERATURE problems turn the heater breaker switch off and assure that the TEMP display falls to 33°C and that the bypass condition exists.

3. If you have been troubleshooting CONDUCTIVITY problems drop the acid and bicarb lines into water and assure that the COND display falls to 10.0 and that the bypass condition exists.

4. Check that AUDIO ALARMS are working properly.

5. Perform alarm and pressure holding tests.

EQUIPMENT NEEDED

- Fresenius gauge kit (part # 150034)

- Fresenius test (temperature) 'dummy connectors' (part # 190060)

- Graduated cylinder (1000 ml)

- Buret 0 - 25cc (part # 290104)

- 60 ml syringe

- Flashlight

- Jumper wire

- Independently calibrated temperature, conductivity, and pressure meters

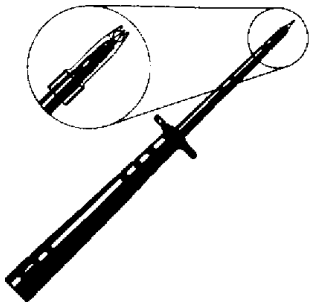
- Voltmeter (recommended Fluke "70" series)

- Clip-on meter leads (recommended Fluke TL24 Flexible test leads with AC80 pin grabbers)

* Non-standard meter probes (recommended Fluke TP80 probes)

* Non-standard meter probes assure safe voltage measurement in 'tight' areas when shorting other pins or connectors is a concern. Fluke TP80 meter probes include a slip-on cap that fits over the lead to 'isolate' the measuring point and prevent shorting.

FLUKE TP80 METER PROBES (WITH SLIP ON CAP)



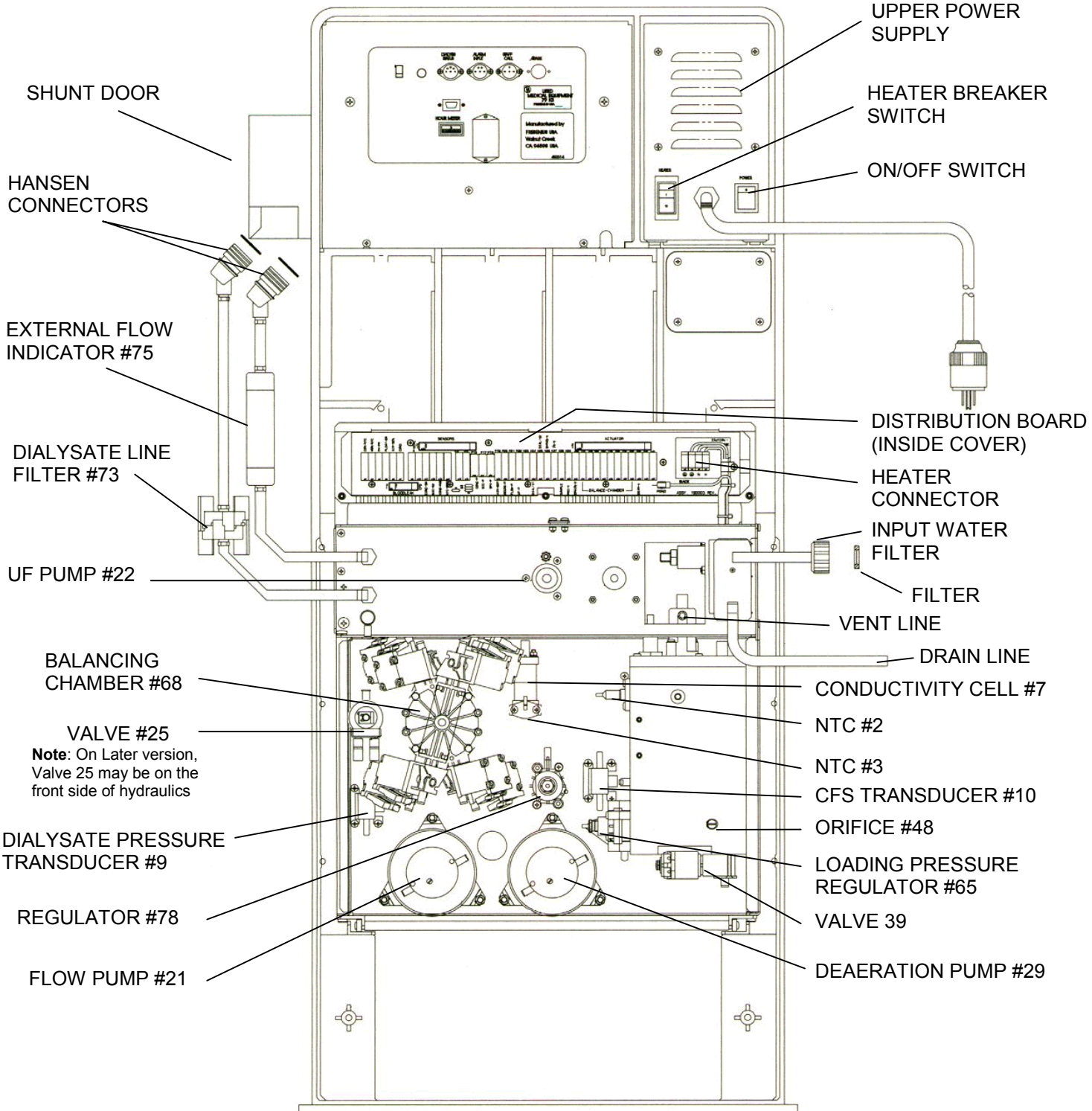


DIAGRAM A REAR VIEW

SECTION 1 - FLOW ERRORS IN DIALYZE MODE

F- 1.0.0 CHECK LOADING PRESSURE

a) Assure that the vent tube is not 'pinched' (see diagram A, page 5) .

b) Insert a *loading pressure gauge **TIGHTLY** into the ACETATE/ACID port. Peak pressure?

1) 0 to 10 psi — Call up debug screen 5. If !WATER = "1" proceed to NO WATER (page 23) otherwise proceed to F- 2.0.0

2) 17 to 25 psi — Allow two minutes (if necessary) for the symptoms to appear. See F- 3.0.0

3) Greater than 25 psi — Attempt to calibrate loading pressure to +19 psi peak per CALIBRATION PROCEDURES, section 2.13. If not successful a bad loading pressure regulator #65 is indicated (see diagram A, page 5).

* If the gauge does not read 0 psi at atmosphere compensate for this during loading pressure checks.

F- 2.0.0 CHECK FOR A RUNNING DEAERATION PUMP

Make sure that flow is on (FLOW ON/OFF LED is off). Depending upon the pump:

1. Motors with brushes The deaeration pump's motor shaft can be accessed from the front side of the machine (see FRONT VIEW diagram below). If the shaft is *rotating the pump is running. Is the deaeration pump running?

   Yes — See F- 14.0.0 (page 12).

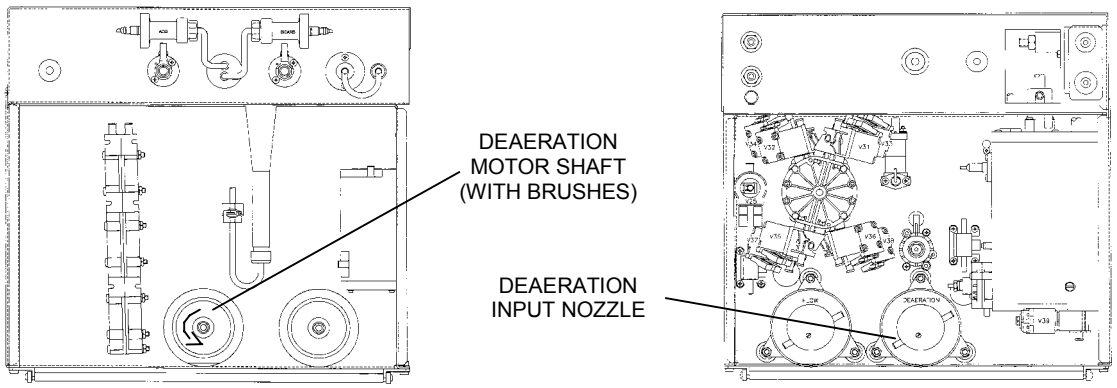
   No — See F- 18.0.0 (page 16) to check the **DEAERATION PUMP**.

* Rotation is CCW (from the front of the machine). If rotating CW the motor is running backwards

2. Motors without brushes Remove the CLEAR tubing from the deaeration pump's input nozzle (see REAR VIEW diagram below). If the pump is running you will hear 'gurgling'. Is the deaeration pump running?

   Yes — See F- 14.0.0 (page 12).

   No — See F- 18.0.0 (page 16) to check the **DEAERATION PUMP**.



FRONT VIEW **REAR VIEW**

F- 3.0.0 CHECK DEBUG ERRORS

CAUTION Do NOT attempt to reset other alarms during this check!

Call up debug screen 5 and watch !WATER and FLWERR for two minutes. Proceed accordingly:

1) !WATER and FLWERR = "0" constantly. See F- 3.0.1

2) !WATER = "1" constantly or intermittently. See NO WATER (page 23).

3) FLWERR = "1" constantly or intermittently. See F- 4.0.0

F- 3.0.1 FLOW ERROR NOT PRESENT

- If COND is CONSTANTLY high. Watch FLWERR for several minutes. If it goes to "1" see F- 4.0.0
- If COND is drifting from normal to high. Wait until the BYPASS LED is off and watch FLWERR for 30 seconds. If it goes to "1" see F- 6.0.0.
- If conductivity remains normal. If FLWERR remains " 0" constantly a flow error is not indicated.
- If conductivity remains low and FLWERR remains "0" a flow error is NOT present.

F- 4.0.0 CHECK FOR FILLING PROGRAM

Call up debug screen 7. Is FILACT "1" or "0"?

"1" See F- 4.0.1

"0" See F- 5.0.0

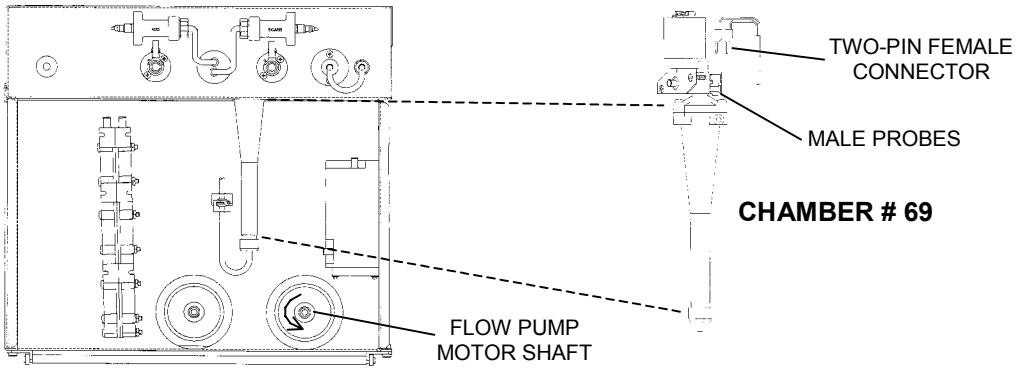
F- 4.0.1 FILLING PROGRAM PRESENT

a) At the top of chamber #69 is a two-pin female connector that plugs onto two male probes (see diagram, below). Unplug both sides of the connector and connect the female ends together. FILACT should now = 0.

b) Return to debug screen 5 and watch for 3 minutes. Does FLWERR go to "0" and REMAIN?

Yes See F- 4.0.2.

No Plug the female connector back onto the probes and see F- 5.0.0.



FRONT VIEW

F- 4.0.2 CHECK FLOW PUMP

From the front side of the machine you can see the flow pump's motor shaft (see FRONT VIEW diagram, previous page). Turn the flow off. Is the shaft rotating?

Yes Replace the actuator board.

No See F- 16.0.0 (page 14).

F- 5.0.0 CHECK FOR A *VALVE ERROR

Proceed with this step ONLY if FILACT and !WATER are both = "0" continuously.

From DIALYZE MODE return to debug screen 5. Watch VLVERR **VERY** carefully for **two full minutes**. If a valve error is present VLVERR 'blinks' momentarily to "1" (about every 60 seconds). If a valve error is present VLVERR goes to "1" for ONLY a second. If you look away you may miss it! Does VLVERR ever 'blink' "1"?

Yes See F- 5.0.1

No See F- 6.0.0

* VALVE ERRORS indicate either high or low current in a particular 'valve circuit'.

F- 5.0.1 LOCATING THE VALVE ERROR

Listen carefully in the area of the hydraulics (you may need to remove them from the machine). You should be able to hear a continuous, dull, 'thudding'. Proceed step-by-step and follow the given instructions.

1) From DIALYZE MODE open the shunt door. If the 'thudding' stops a **VALVE 25** is causing the error. Note this (valve 25 is the problem) and see TROUBLESHOOTING VALVE ERRORS (page 30). If the 'thudding' continues proceed to step 2.
2) Turn the flow off. If the 'thudding' stops a BALANCING CHAMBER VALVE is causing the error. Note this (balancing chamber valve is the problem) and see TROUBLESHOOTING VALVE ERRORS (page 30). If the 'thudding' continues proceed to step 3.
3) The 'thudding' continues with the shunt door open and flow off. **VALVE 30** or **26** is causing the error. Note this (valve 30 or 26 is the problem) and see TROUBLESHOOTING VALVE ERRORS (page 30). Troubleshoot **BOTH** valves.

F- 6.0.0 CHECK FLOW ERROR 'IN BYPASS'

Open the shunt door to cause bypass. Return to debug screen 5 and watch FLWERR for **one full minute**. Does FLWERR go to "0" constantly or does it still = "1" (either constant or intermittent)?

"0" constantly See F- 6.0.1

Still = "1" Close the shunt door and see F- 7.0.0

F- 6.0.1 CHECK FLOW ERROR 'OUT OF BYPASS'

a) Leave the shunt door open and return to the main DIALYSIS screen.

b) Allow TEMP and COND to become normal.

c) Close the shunt door (bypass LED should turn off) and return to debug screen 5. Wait 30 seconds. Does FLWERR = "1"?

Yes See F- 17.0.0 (page 15).

No A flow error is not indicated.

F- 7.0.0 CHECK FOR A RUNNING FLOW PUMP

CAUTION Do NOT attempt to reset other alarms during this check!

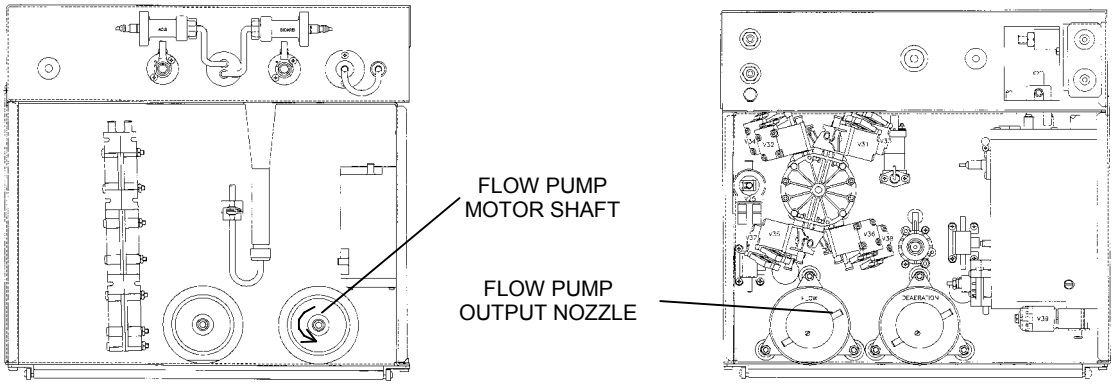
a) At this time NOTE if FLWERR = "1" constantly or intermittently for future use.

b) From the FRONT of the machine you can see the flow pump's motor shaft (see FRONT VIEW diagram below). If the shaft *rotating?

Yes See F- 8.0.0

No See F- 18.0.0 (page 16) to check the **FLOW PUMP**.

* Rotation is CCW (from the front of the machine). If rotating CW the motor is running backwards



FRONT VIEW **REAR VIEW**

F- 8.0.0 CHECK FLOW PUMP CONTROL

Turn the flow off and check the flow pump's motor shaft again. Still rotating?

Yes Replace the actuator board (pump driver (IC18) possibly shorted).

No a) Turn the flow on.

b) FLWERR may = "0" for a few seconds after turning flow on. Ignore this! As noted previously (step F- 7.0.0) was FLWERR = "1" constant or intermittent?

Constant See F- 10.0.0

Intermittent See F- 9.0.0

F- 9.0.0 CHECK FOR NO WATER

Turn the flow on and call up debug screen 5 and carefully watch !WATER for **two minutes**. Does !WATER go to "1" at any time during this time interval?

Yes See NO WATER (page 23).

No See F- 9.0.1

F- 9.0.1 CHECK FLOW PUMP PRESSURE

a) Tee a pressure gauge between the flow pump's output nozzle and the WHITE tubing (see REAR VIEW diagram, previous page).

b) Turn the flow on at a 500 flow rate. Does pressure peak to 14 psi or greater?

Yes See F- 13.0.0 (page 12)

No Three possibilities: 1) Bad actuator board; 2) Bad flow pump head; 3) Bad flow pump motor.

F- 10.0.0 CHECK DRAIN FLOW

a) Having a bucket handy and go to end of the drain line. Hold it UP, at a 45 degree angle, over the bucket. CAUTION! Holding the drain line lower than 45 degrees makes this test invalid!

b) Watch for 20 seconds. Flow may be intermittent and this is normal. Is there any flow through the drain line?

Yes See F- 10.1.0

No See F- 11.0.0

F- 10.1.0 DETERMINING DRAIN FLOW

Normal Fresenius drain output 'pulses' in 30 ml increments, stops completely, and then 'pulses' out again. Is drain flow 'pulsing' or 'continuous' (never stops)?

Pulsing — See F- 13.0.0 (next page).

Continuous — Three possibilities: 1) Partial restriction to drain (check the drain line first for restrictions); 2) Balancing chamber valve remaining open (run automated valve leak test from SERVICE/DIAGNOSTICS); 3) Leaking balancing chamber diaphragm (see TESTING FOR A LEAKING BALANCING CHAMBER DIAPHRAGM).

F- 11.0.0 CHECK FLOW TO (DRAIN) VALVE 30

CAUTION! During this procedure there will be spillage. Move the hydraulics away from the cabinet to prevent spillage into the cabinet!

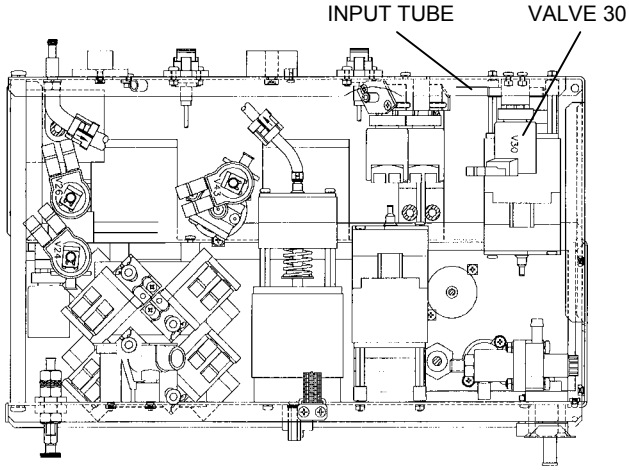
a) Turn the flow off and remove the INPUT tube from valve 30 (see TOP VIEW diagram below). Point it AWAY from the hydraulics.

b) Turn the flow on. Is there good 'pulsing' flow here?

Yes — Turn flow off and attach the tubing to valve 30. See F- 11.1.0

No — See F- 12.0.0

TOP VIEW



REAR OF MACHINE

F- 11.1.0 CHECK VALVE 30

a) Turn the flow on.

b) Remove the drain line from the back of the machine. Is there good 'pulsing' flow here?

Yes — The drain line is restricted.

No — A problem is indicated with **VALVE 30** or the actuator board. **NOTE** this and see TROUBLESHOOTING VALVES (page 29).

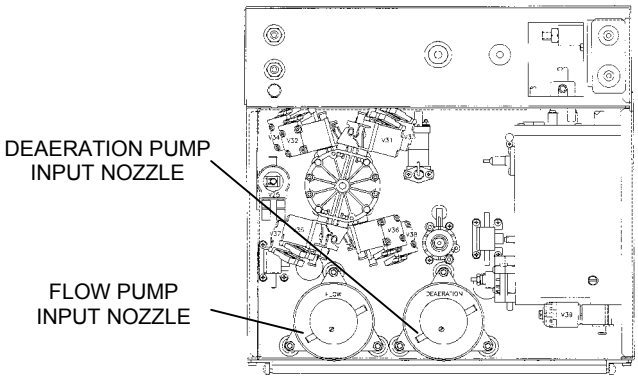
F- 12.0.0 CHECK FLOW TO FLOW PUMP

Proceed with this step if you are VERY sure that VLVERR (debug screen 5) is always "0".

Place the machine into RINSE and remove the CLEAR tube from the flow pump's INPUT nozzle (see diagram below). Good flow here?

Yes A problem is indicated with **VALVE 26** or the actuator board. **NOTE** this and see TROUBLESHOOTING VALVES (page 29).

No Replace the actuator board. If the flow error continues there may be two bad valves (remaining closed) on the balancing chamber.



REAR VIEW

F- 13.0.0 CHECK CFS SIGNAL

Making sure that flow is on call up debug screen 11 and watch ACFS (in vdc). SIX possibilities:

1) Constant flow error and ACFS remaining between 3 and 7. See F- 21.0.0 (page 20).
2) Constant flow error and ACFS remaining between 8 and 11. See F- 23.0.0 (page 22).
3) Constant flow error and ACFS remaining between 0 and 3. See F- 20.0.0 (page 18).
4) Intermittent flow error and ACFS remaining between 3 and 7. See F- 21.0.0 (page 20).
5) Intermittent HIGH FLOW error. Call up debug screen 10 and watch CFS for a couple of minutes. If CFS intermittently 'bounces' to about 10 replace the CFS transducer (#10). If the problem continues check for a bad connection at the sensor board cable on both sides (especially the distribution board side, unplug the cable and check the male pins for corrosion). There may also be an intermittent open in the sensor cable or a problem with the sensor or actuator boards.
6) Intermittent flow error and ACFS 'bouncing' (about every 9 seconds) from between 0 and 3 to about 5. A problem is indicated with a BALANCING CHAMBER VALVE. See F- 19.0.0 (page 16).

F- 14.0.0 LOW LOADING PRESSURE, DEAERATION PUMP RUNNING

NOTE: This procedure checks for water in the hydroblock and proper float functional.

a) Stop the deaeration pump by unplugging it from distribution board position P20, DEAR-P.
b) If you haven't done so remove the CLEAR (input) tube from the deaeration pump's nozzle (see REAR VIEW diagram, above). Is there flow from the tube?

Yes See F- 14.0.1

No See F- 15.0.0

F- 14.0.1 CHECK INCOMING WATER

Allow this flow to continue for about three minutes (you may need a bucket). You should hear water entering the hydroblock in cycles as the float falls and rises. Does flow remain continuous?

Yes See F- 14.0.2

No See F- 15.0.0

F- 14.0.2 CHECK LOADING PRESSURE REGULATOR

a) Plug the deaeration pump back into the distribution board (P20, DEAR-P) and assure that it starts running i.e. the motor shaft rotates. Allow one minute and check if loading pressure returns to normal (19 ± 1 psi). If it does there may be an intermittent problem with the float. Continue to part b otherwise.

b) Tightly clamp the solid tubing between the loading pressure regulator and the hydroblock (see diagram below). Is there a drastic increase of loading pressure?

Yes A problem is indicated with the loading pressure regulator.

No A problem is indicated with the deaeration pump head.

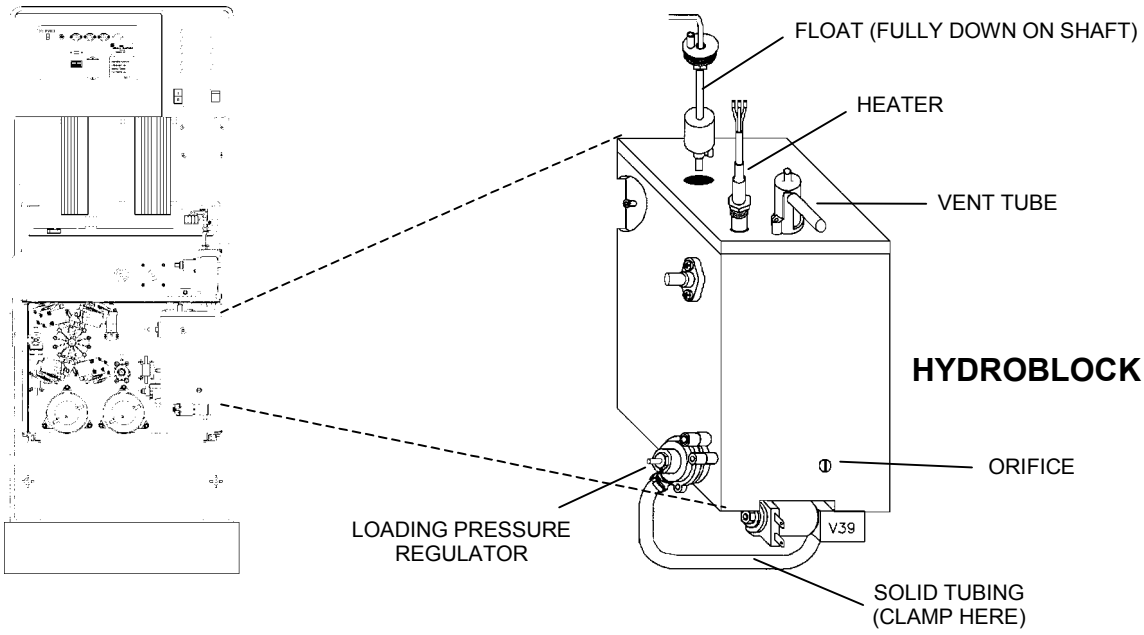
F- 15.0.0 CHECK HYDROBLOCK

a) Clamp the vent tube and remove the orifice from the hydroblock (see diagram below). Check if it is plugged. If plugged this is the problem.

b) Re-install the orifice and **REMOVE** the clamp from the vent tube.

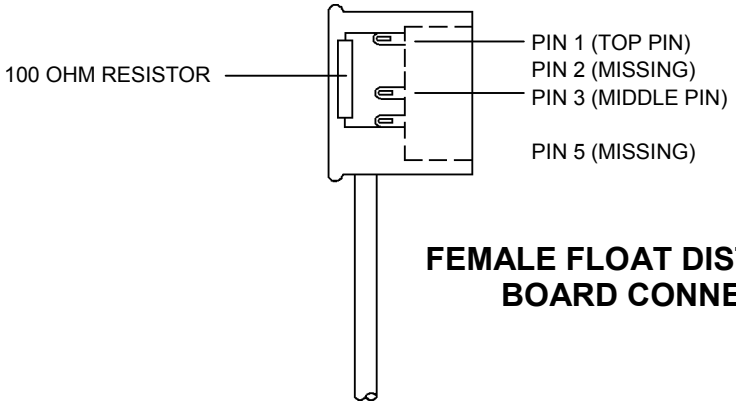
c) Turn the power off.

d) Loosen (but don't remove) the screws that mounts the float into the hydroblock (see diagram below). **CAUTION** Don't pull on the float's wiring harness or you may break it! Carefully remove the float from the hydroblock.



e) Unplug the float from distribution board position FLOAT-SW. Check inside the distribution board for bent broken or corroded male pins.

f) Very carefully open the cover on the female connector (see diagram below). Note that pins 2 and 5 are missing. Clip meter leads onto pins 1 and 3 (pin 1 = top of the 100 ohm resistor, pin 3 = middle pin). CAUTION! Be careful to clip onto the correct pins!



FEMALE FLOAT DISTRIBUTION BOARD CONNECTOR

g) With the float **FULLY DOWN** on the shaft you should read approximately 100Ω, **FULLY UP** an 'open' (OL). Move the float FULLY UP and DOWN twenty times while watching the transition on the meter. It should go from OL to 100Ω everytime! If the float checks out good see F- 15.0.1

F- 15.0.1 CHECK INCOMING WATER

a) Plug the float's connector back into the distribution board (position FLOAT-SW).

b) Hold the float in its **FULLY UP** position. Turn the power on and wait until the SELECT PROGRAM screen is up.

c) Looking into the hydroblock's float cavity turn the power on. **CAUTION** Avoid overflow during this step! Move the float to its FULLY DOWN position. Is the water level rising?

Yes See F- 15.0.2

No Two possibilities: 1) *Bad sensor board cable; 2) Bad actuator board.

* The sensor cable can be checked for continuity. Note that you are checking the **FLOAT** connection and see CHECKING THE SENSOR BOARD CABLE (page 74).

F- 15.0.2 CLEARING AN AIR LOCK

a) Connect a 60 ml syringe to the clear INPUT tubing of the deaeration pump and draw on it. You may have to pull five or six syringes full of air before water flows continuously by itself. If you are not able to make water flow continuously it may be indicative of a 'stripped' orifice.

b) Re-connect the INPUT tubing to the deaeration pump and plug the deaeration pump back into the distribution board (P20, DEAR-P). Assure that it starts running i.e. the motor shaft rotates. Allow a few minutes for loading pressure to return to normal. **NOTE**: Recurring air locks may be indicative of a bad deaeration pump head, motor or a 'stripped' orifice.

F- 16.0.0 TROUBLESHOOTING 'FILLING PROGRAM' FLOW ERRORS

During **FILLING PROGRAMS** the dialysate pressure transducer #9 determines the presence of flow.

a) Plug the connector back onto the probes.

b) Remove the dialysate lines from the shunt door and drop them into a bucket of water on the floor.

c) **IMPORTANT** Close the shunt door.

d) Call up debug screen 9 and wait 30 seconds. Is PDIA between 4.0 and 6.0 vdc?

Yes See F- 16.0.1

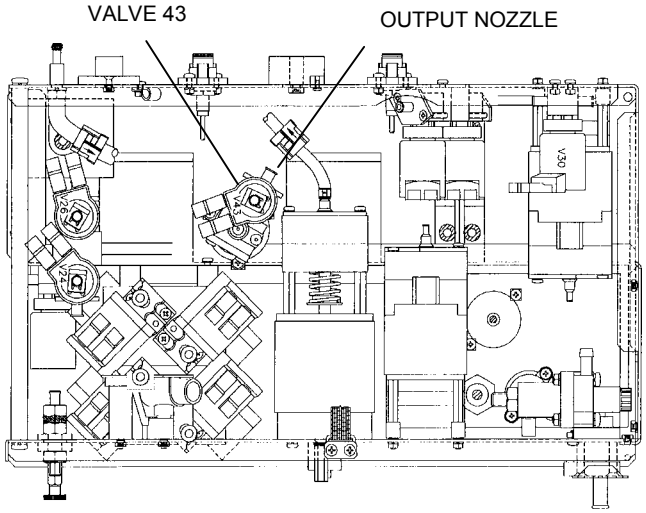
No See TM- 2.0.1, TMP PROBLEMS (page 58).

F- 16.0.1 CHECK VALVE 43

CAUTION! During this procedure there will be spillage. Move the hydraulics away from the cabinet to prevent damage.

a) Place the machine into RINSE.

b) Clamp and remove the tubing from the valve 43's output nozzle (see diagram below).



HYDRAULICS, TOP VIEW

c) Call up debug screen 20. When V43= 1 the actuator board is sending a signal to open valve 43. This occurs every two minutes for several seconds. When V43= 1 is there flow from valve 43's nozzle?

Yes Flow errors sometimes occur if a FILLING PROGRAM is prolonged.

No A problem is indicated with **VALVE 43** or the actuator board. **NOTE** this and see CHECKING VALVES (page 28).

F- 17.0.0 TROUBLESHOOTING FLOW ERRORS 'OUT OF BYPASS'

A problem is indicated in the 'out of bypass' circuit which includes the external dialysate filter (73), valves 24 and 25. **CAUTION!** There will be spillage during this procedure. Make sure the card cage is closed!.

a) Place the machine into RINSE.

b) Open the shunt door and remove the RED dialysate line. Is there flow from the shunt door?

Yes a) Stop RINSE by pulling the red concentrate connector from its port

b) Check the external dialysate line filter #73 (see diagram A, page 5). If the filter is clean a problem is indicated with **VALVE 25** or the actuator board. **NOTE** this and see TROUBLESHOOTING VALVES (page 29).

No A problem is indicated with **VALVE 24**, the actuator board or actuator cable. **NOTE** this and see CHECKING VALVES (page 28).

F- 18.0.0 TROUBLESHOOTING PUMPS

Proceed ONLY with the pump of interest.

a) Make sure that flow is on and the proper flow rate is selected as directed in the table below.

b) Unplug the noted pump from the distribution board. Check, inside the distribution board, for bent, broken, or corroded male pins.

c) Measure dc voltage, inside the distribution board, between male pins 1 and 5 (top and bottom).

PUMP	DISTRIBUTION BOARD POSITION	FLOW RATE (ml/min)	VOLTAGE RANGE	BAD
DEAERATION	P20, DEGAS-P	500	16 vdc or greater	Replace the pump head
			Less than 16 vdc	Two Possibilities: 1. [1]Actuator cable 2. Actuator board
FLOW	P21, FLOW-P	800	12 vdc or greater	Replace the pump head
			Less than 12 vdc	Two Possibilities: 1. [2]Actuator cable 2. Actuator board

[1] The actuator cable can be checked for continuity. Note that you are checking **DEAERATION PUMP** connections and see CHECKING THE ACTUATOR BOARD CABLE (page 72).

[2] The actuator cable can be checked for continuity. Note that you are checking **FLOW PUMP** connections and see CHECKING THE ACTUATOR BOARD CABLE (page 72).

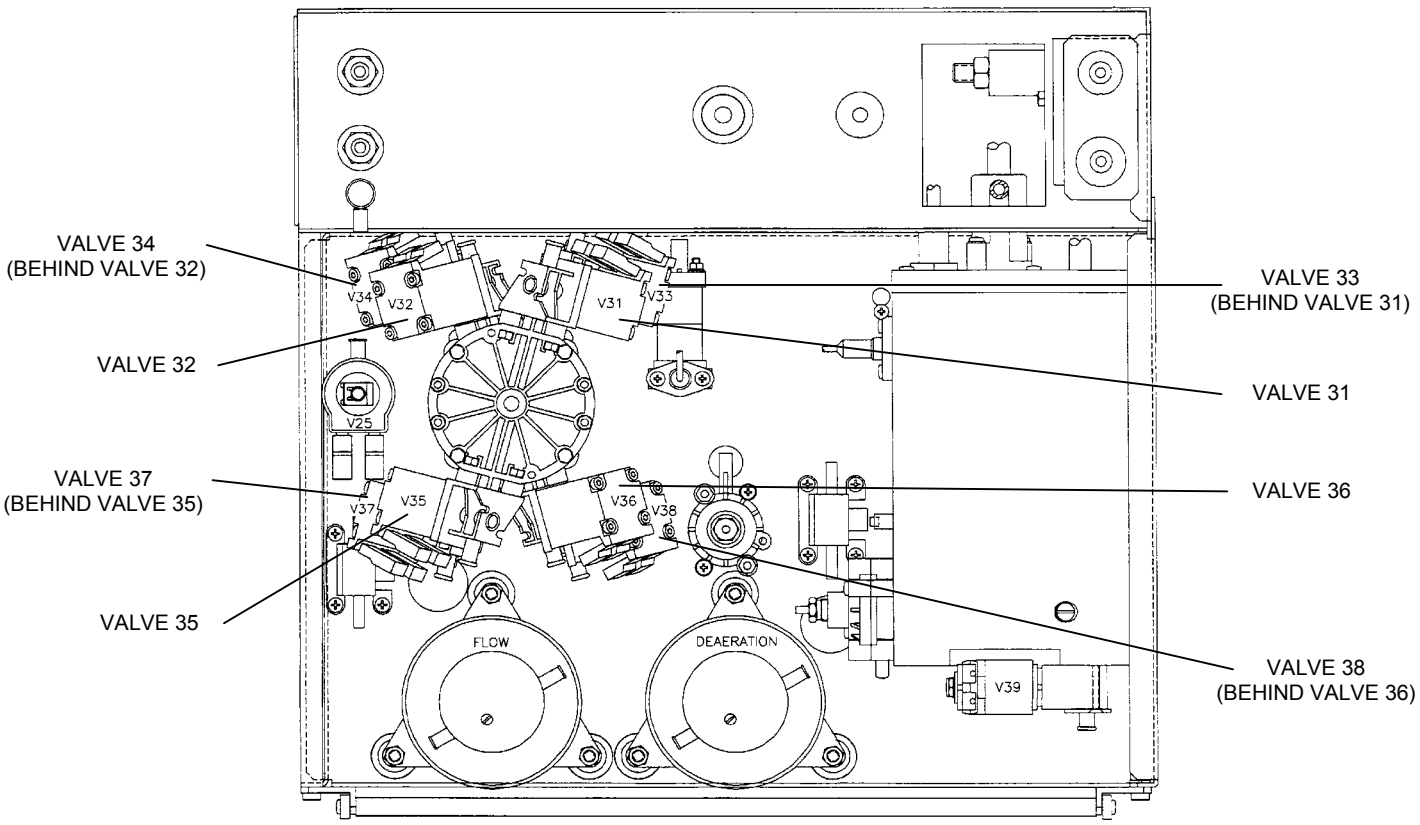
F- 19.0.0 TROUBLESHOOTING BALANCING CHAMBER VALVES

A balancing chamber valve may be remaining open or closed at all times.

a) Check that all balancing chamber valves are plugged into the distribution board at their proper positions (V31 through V38). If ok proceed.

b) Turn the power off and swap in a good actuator board.

c) Put the machine back into dialyze mode. Call up debug screen 5 and watch FLWERR for **several** minutes. If the flow error is still intermittent see F- 19.0.1.



HYDRAULICS, REAR VIEW

F- 19.0.1 CHECKING VALVES 36 AND 38

NOTE: The previous actuator board is good.

a) Turn the machine off and then back on. Wait until the SELECT PROGRAM screen is up.

b) **IMPORTANT!** Do **NOT** place the machine into dialyze mode. From SELECT PROGRAM is there flow to the drain?

Yes — Using a metal clamp tightly clamp the solid tubing at balancing chamber valve 36 (see diagram, above). If flow stops replace valve 36. If not replace valve 38.

No — See F- 19.0.2

F- 19.0.2 CHECKING VALVE 32

Unplug valves 32 and 36 from the distribution board (V32 and V36). Plug 36 into 32's position and visa versa. If there is flow to the drain replace valve 32. If not carefully plug both valves back into their proper distribution positions and see F-19.0.3

F- 19.0.3 CHECKING VALVE 34

Unplug valves 34 and 38 from the distribution board (V34 and V38). Plug 34 into 38's position and visa versa. If there is flow to the drain replace valve 34. If not carefully plug both valves back into their proper distribution board positions and see F-19.0.4.

F- 19.0.4 CHECKING FOR CLOSED BALANCING CHAMBER VALVES

Place the machine into dialyze mode and TIGHTLY clamp the clear tubing at valve 31 (see diagram, above). From debug screen 5, does FLWERR now go constant "1"?

Yes Referencing the flow diagram, the problem is a valve in the right-side balancing chamber. See F- 19.0.5

No FLWERR remains intermittent. Referencing the flow diagram, the problem is a valve in the left-side balancing chamber. See F- 19.0.6

F- 19.0.5 'RIGHT-SIDE' VALVE BAD

a) Turn the power off and unplug valves 37 and 34 from the distribution board (positions V37 and V34).

b) Plug valve 37 into 34's position (V34), leaving valve 34 unplugged.

c) **IMPORTANT!** Do **NOT** place the machine into dialyze mode. From SELECT PROGRAM check drain flow. Is there strong flow to the drain?

Yes Note that either valve 38 or 34 is not opening and see F- 19.0.7

No Note that either valve 37 or 33 is not opening and see F- 19.0.7

F- 19.0.6 'LEFT-SIDE' VALVE BAD

a) Turn the power off and unplug valves 35 and 32 from the distribution board (positions V35 and V32).

b) Plug valve 35 valve 32's position (V32), leaving valve 32 unplugged.

c) **IMPORTANT!** Do **NOT** place the machine into dialyze mode. From SELECT PROGRAM check drain flow. Is there strong flow to the drain?

Yes Note that either valve 32 or 36 is not opening and see F- 19.0.7

No Note that either valve 35 or 31 is not opening and see F- 19.0.7

F- 19.0.7 CHECK FOR A 'MECHANICALLY STICKING' VALVE

a) Check the noted valve's distribution board connector position for bent, broken or corroded male pins.

b) Carefully plug all valves back into their proper distribution board position.

c) Place the machine into dialyze mode and call up debug screen 7. FILACT **MUST** = "0" to continue.

d) If the valve bodies are clear check the valve plungers for movement and replace the one that is not moving. If the valve bodies are solid, swap one of the valves and check for flow errors.

F- 20.0.0 ACFS BETWEEN 0 AND 3

The CFS transducer is acting like a 'short'. Turn flow off. Does ACFS go to between 3 and 7?

Yes **IMPORTANT** turn flow on and return to F- 7.0.0 (the CFS transducer is good).

No See F- 20.0.1

F- 20.0.1 CHECK CFS CIRCUIT

Unplug the CFS transducer from the distribution board (position CFS). Check, for bent, broken or corroded male pins. Is ACFS between 8 and 11?

Yes See F- 20.0.2

No ACFS remains between 0 and 3. See F- 20.0.7

F- 20.0.2 CHECK SENSOR BOARD CFS VALUE

Leave the transducer unplugged and call up debug screen 10. Is CFS between 8 and 11?

Yes See F- 20.0.3

No Replace the sensor board.

F- 20.0.3 CHECK FOR A LEAKING BALANCING CHAMBER VALVE

a) Plug the CFS transducer back into the distribution board and assure that ACFS returns to between 0 and 3.

b) Turn the flow on and push SET to return to the DIALYSIS screen. Is TMP pegged at +60?

Yes See F- 20.0.4

No Replace the CFS transducer (see diagram, next page).

F- 20.0.4 CHECK FOR A LEAKING BALANCING CHAMBER VALVE

a) Push and release the RESET button on the front panel. The message "ADJUST TMP?" appears.

b) Immediately push and HOLD the RESET button. After the "ADJUSTING TMP" message is gone does TMP return to +60 or remain relatively stable?

+60 See F- 20.0.5

Stable Replace the CFS transducer (see diagram, next page).

F- 20.0.5 CHECK FOR A LEAKING BALANCING CHAMBER VALVE

a) Place the machine into SERVICE/DIAGNOSTICS.

b) Select and enter #11 VALVE LEAK TEST. Wait until the "READY" message appears.

c) Push SET **TWICE** to start the test. Is a leaking valve indicated?

Yes Note the leaking valve and see F- 20.0.6

No Replace the CFS transducer (see diagram, next page).

F- 20.0.6 CHECK FOR SHORTED VALVE DRIVER

a) Unplug the **NOTED** valve from the distribution board.

b) Measure dc voltage, inside the distribution board, between male pins 1 and 5 (top and bottom). One volt or greater?

Yes Replace the actuator board.

No Replace the indicated leaking valve.

F- 20.0.7 TROUBLESHOOTING THE CFS CIRCUIT

Leave the transducer unplugged for now and call up debug screen 10. Is CFS also between 0 and 3?

Yes See F- 22.0.0

No Between 8 and 11. Replace the actuator board.

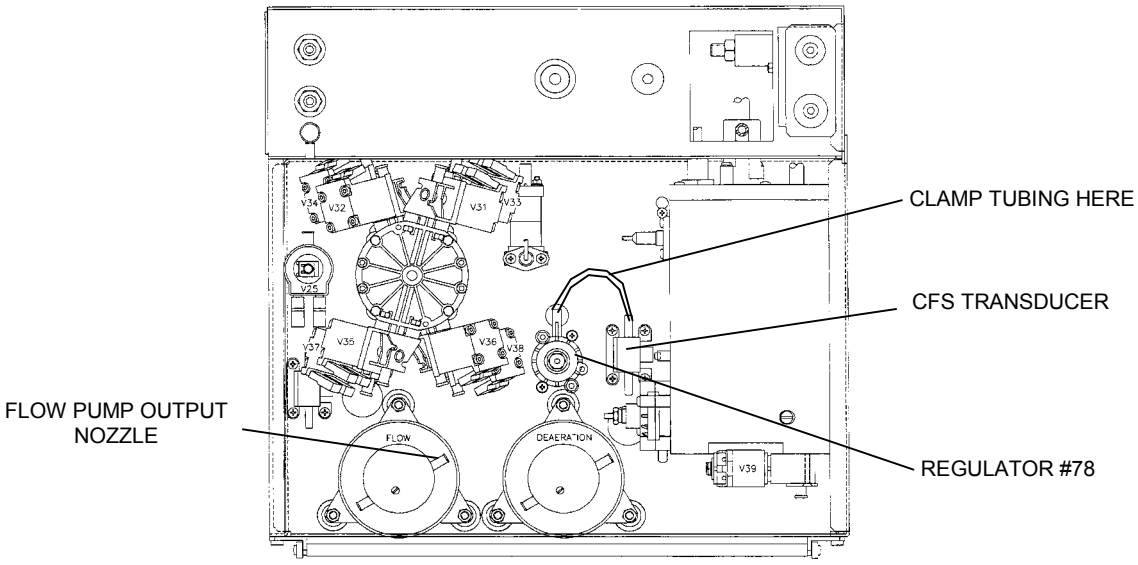
F- 21.0.0 ACFS BETWEEN 3 AND 7

The CFS transducer is not switching the balancing chamber valves properly.

Clamp the solid tubing between the output of the CFS transducer and regulator #78 (see diagram below). Does ACFS go to below 2 now?

Yes Replace regulator #78 (see diagram below).

No See F- 21.0.1



REAR VIEW

F- 21.0.1 CHECK FLOW PUMP PRESSURE

1) Remove the clamp.

2) Turn the flow off and tee a psi gauge between the flow pump's output nozzle and the SOLID tubing (see diagram on previous page).

3) Turn the flow on at a 500 flow rate. Does pressure peak to 14 psi or greater?

   Yes See F- 21.0.2

   No Three possibilities: 1) Bad actuator board; 2) Bad flow pump head; 3) Bad flow pump motor.

F- 21.0.2 CHECK CFS CIRCUIT

Unplug the CFS transducer from the distribution board (position CFS) and check for bent, broken or corroded male pins. Is ACFS between 8 and 11?

   Yes See F- 21.0.3

   No ACFS remains between 3 and 7. See F- 21.0.4

F- 21.0.3 CHECK SENSOR BOARD CFS VALUE

Leave the CFS transducer unplugged and call up debug screen 10. Is CFS between 8 and 11?

   Yes a) Plug the CFS transducer back into distribution board (position x10, CFS).

   b) If CFS remains between 3 and 7 and the flow error is still present there are four possibilities: 1) Bad actuator board; 2) Bad flow pump head; 3) Bad flow pump motor motor; Bad CFS transducer (see diagram, previous page).

   No Replace the actuator board.

F- 21.0.4 TROUBLESHOOTING THE CFS CIRCUIT

Leave the transducer unplugged for now and call up debug screen 10. Is CFS also between 3 and 7?

   Yes See F- 22.0.0

   No Between 8 and 11. Replace the actuator board.

F- 22.0.0 CHECK SENSOR BOARD CABLE

a) Turn the power off and unplug the 34-pin ribbon cable from the top of the sensor board [card cage, smallest board, right hand side].

b) Turn the power on.

c) Push the SET button ONCE to enter the VERIFY CONCENTRATE screen

d) Call up debug screen 11. Is CFS between 8 and 11 now?

   Yes Unplug both sides of the 34-pin ribbon cable from the sensor and distribution board's SENSORS connector. Look for bent male pins inside each connector. If ok replace the 34-pin ribbon cable.

   No Three possibilities: 1) Bad sensor board; 2) Bad actuator board; 3) Bad functional board;

F- 23.0.0 ACFS BETWEEN 8 AND 11

An CFS transducer is acting 'open'. There are several possibilities that may cause this symptom.

Call up debug screen 10. Is CFS also reading between 8 and 11?

Yes See F- 23.0.1

No Replace the actuator board.

F- 23.0.1 CHECK CFS TRANSDUCER FOR AN 'OPEN'

a) Unplug the CFS transducer from distribution board position CFS. Check, inside the distribution board, for bent, broken or corroded male pins.

b) Plug the 34 degree Fresenius temperature 'dummy connector' into the CFS's distribution board position (CFS). Does CFS go to between 0 and 2?

Yes [1]Replace the CFS transducer (see diagram, page 20).

No Two possibilities: 1) [2]Bad sensor board cable; 2) Bad sensor board.

[1] Before replacing the transducer, check if there is a pig tail extension in the cable between the transducer and the distribution board. If present make sure it is plugged in properly using the 'key' on the pig tail connector. The pig tail is not present in all cases.

[2] The sensor cable can be checked for continuity. Note that you are checking **CFS TRANSDUCER** connections and see CHECKING THE SENSOR BOARD CABLE (page 74) .

SECTION 2 - NO WATER

NW- 1.0.0 CHECK INCOMING WATER SYSTEM

a) Assure that the water is on and that the vent tube is not 'pinched' (see diagram A, page 5).

b) Turn the water off and check the input water filter for restrictions (see diagram A, page 5).

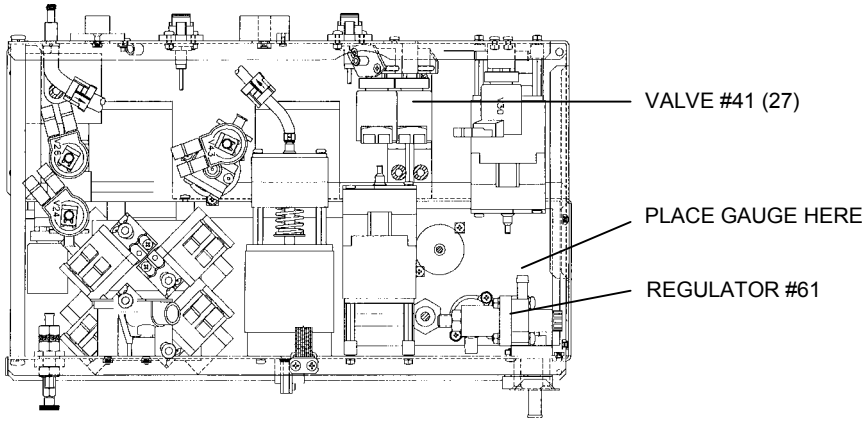
c) Before hooking the incoming water line back up assure that there is adequate incoming water flow.

d) Tee a pressure gauge at the output of side of pressure regulator #61 (see TOP VIEW diagram below) and hook the incoming water line to the machine.

e) Turn the water on and assure that the machine is in **DIALYZE** mode. Pressure 19 ± 1 psi at its peak?

Yes See NW- 2.0.0

No Attempt calibration (see section 3.1, CALIBRATION MANUAL). If calibration is not possible a bad pressure regulator #61 is indicated.



HYDRAULICS, TOP VIEW

NW- 2.0.0 CHECK INCOMING WATER

a) Unplug the float connector from the distribution board (position x5, FLOAT-SW). Check, inside the distribution board, for bent, broken or corroded male pins.

b) Place a jumper wire, inside the distribution board, between male pins 1 and 3 (top and middle pins). The jumper simulates the float switch being 'closed' and should open valve #41 (27). After no more than one minute is there overflow from the vent tube?

Yes See NW- 3.0.0

No Leave the jumper in place. A problem is indicated with **VALVE 41 (27),** the actuator board or the actuator cable. NOTE this and see CHECKING VALVES (page 28).

NW- 3.0.0 CHECK FOR INTERMITTENT BAD FLOAT SWITCH

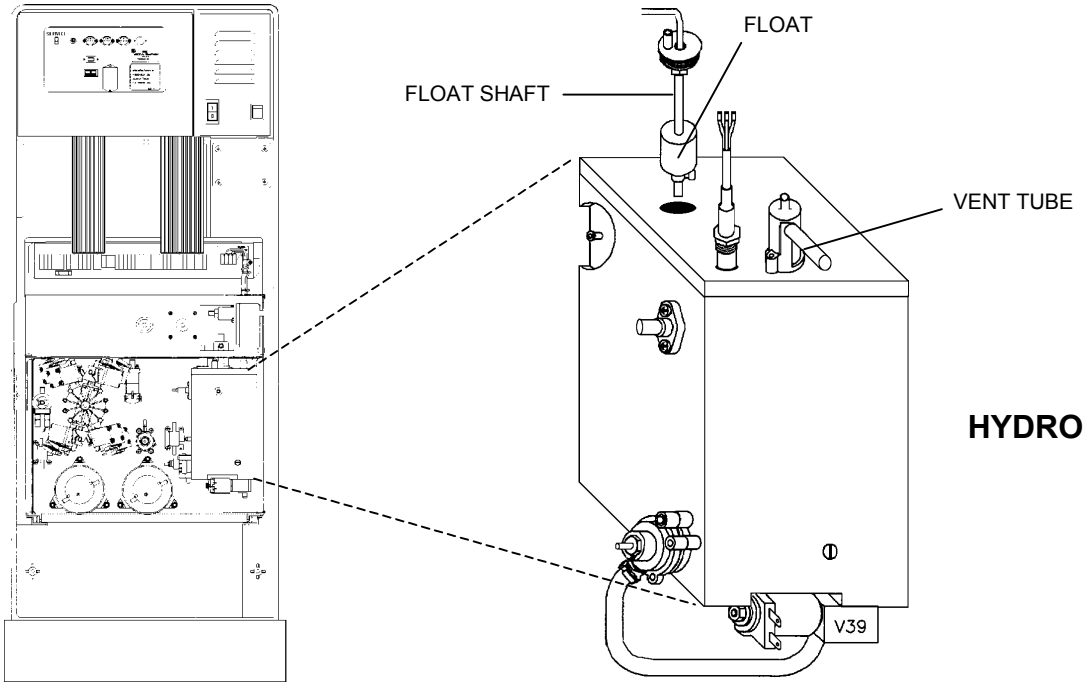
a) Loosen (but don't remove!) the screws that mount the float into the hydroblock (see HYDROBLOCK diagram, next page). **CAUTION!** Don't pull the float's wiring harness.

b) Unplug the float from distribution board position FLOAT-SW. Check inside the distribution board for corroded male pins.

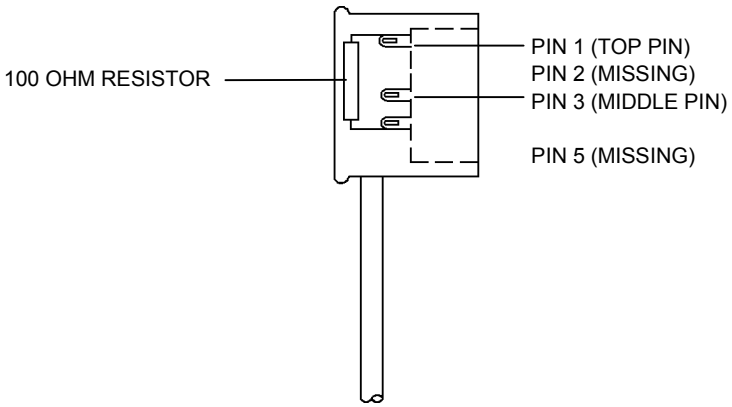
c) Very carefully open the cover on the female connector (see diagram below). Note that pins 2 and 5 are missing. Clip meter leads onto pins 1 and 3 (pin 1 = top of the 100 ohm resistor, pin 3 = middle pin. See FLOAT CONNECTOR diagram below). **CAUTION!** Be careful to clip onto the correct pins!

d) Move the float UP and **FULLY DOWN** twenty times. You should measure about 100 Ω every single time when the float is **FULLY DOWN**. If the float checks good there are four possibilities:

1) Unplug both the actuator and sensor board cables from both ends and check the male connectors and female end for corrosion;
2) Check along the length of the sensor and actuator cables for damage;
3) Check for adequate flow from the incoming water supply;
4) Check incoming water pressure (between 20 and 105 psi).



HYDROBLOCK



SECTION 3 - FLOW ERRORS IN CLEANING PROGRAMS

IMPORTANT NOTE: If flow errors are occurring in HEAT DISINFECT proceed to CP- 1.0.0. If flow errors are occurring in other CLEANING PROGRAMS proceed to CP- 2.0.0.

CP- 1.0.0 FLOW ERRORS OCCURRING SPECIFICALLY IN HEAT DISINFECT

a) Turn the power off and then back on.

b) Pull the concentrate lines out of the port and place them in concentrate. Place the machine in DIALYZE MODE.

c) Allow temperature to become normal (about 37°C) and call up debug screen 5. Watch FLWERR for three minutes. Does FLWERR = "1" either intermittently or constant?

Yes Return to F- 1.0.0 (page 6).

No See CP- 1.0.1

CP- 1.0.1 CHECK FOR FLOW ERRORS IN RINSE

a) Place the concentrate lines back into their ports and place the machine into RINSE.

b) Call up debug screen 5 and watch FLWERR for three minutes. Does FLWERR = "1" either intermittently or constant?

Yes Pull the concentrate lines out of the port and place them in concentrate. Place the machine back into DIALYZE MODE and see CP- 3.0.0 (page 26).

No See CP- 1.0.2

CP- 1.0.2 CHECKING VALVE 39

a) Pull the concentrate lines out of the port and place them in concentrate. Place the machine back into DIALYZE MODE.

b) Check deaeration vacuum per procedure (-24 inHg to -25 inHg). Note the pressure value, leave the gauge in line, and then place the machine into RINSE.

c) Pressure should be at least 10 inHg less than it was in dialyze mode. For example, if you were reading -24 inHg in DIALYZE mode you should read -14 inHg (or less). Is this ok?

Yes If the flow error is occurring only in HEAT DISINFECT, especially after temperature increases, a problem may be indicated with the deaeration pump head or motor.

No Leave the machine in RINSE. A problem is indicated with VALVE 39, the actuator board or the actuator cable. NOTE this and see CHECKING VALVES (page 28).

CP- 2.0.0 FLOW ERRORS IN RINSE, ACID CLEAN, CHEMICAL CLEAN

NOTE: If the machine will only allow RINSE use another machine's functional board. To avoid calibration reference errors turn functional board switch #7 'on' to enter T & C mode. When troubleshooting is complete put the original board back in.

a) Turn the power off and back on. Connect to concentrate and return to DIALYZE MODE.

b) Allow the machine to run for five minutes.

c) Call up debug screen 5 and watch FLWERR for three minutes. Does FLWERR = "1" either intermittently or constant?

Yes Return to F- 1.0.0 (page 6).

No See CP- 3.0.0

CP- 3.0.0 CHECK TMP

In the cleaning modes the dialysate pressure transducer #9 checks for flow. This procedure checks the transducer.

From DIALYZE MODE is the TMP display pegged at either +60 or 520 mmHg?

Yes See CP- 3.0.1

No See CP- 4.0.0

CP- 3.0.1 RESET TMP

a) Push and release the RESET button on the front panel. The message "ADJUST TMP?" appears.

b) Immediately push and HOLD the RESET button. After the "ADJUSTING TMP" message is gone does TMP remain (or return) to its pegged value?

Yes See TMP PROBLEMS (page 57).

No See CP- 4.0.0

CP- 4.0.0 CHECK VALVE 43

CAUTION During these procedures there will be spillage. Move the hydraulics away from the machine to prevent damage.

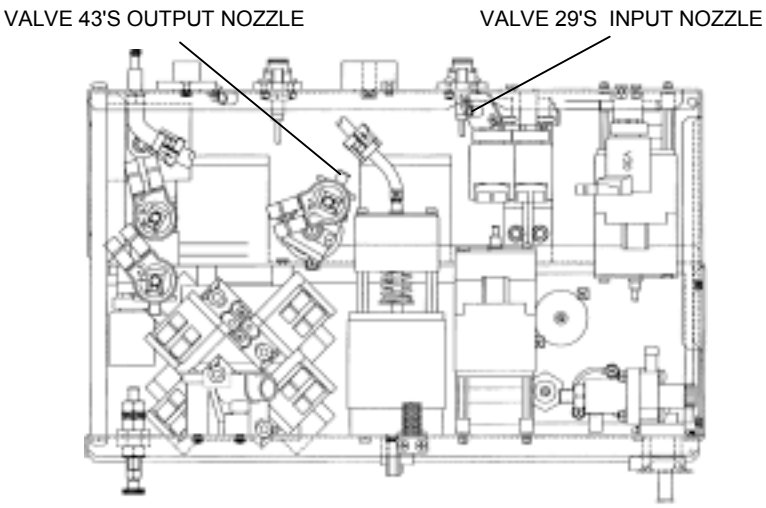
a) Place the dialysate lines into the shunt and the concentrate connectors into their ports.

b) Clamp and remove the clear tubing from valve 43's output nozzle (see diagram below).

c) Put the machine into RINSE and call up debug screen 20. When V43= "1" the actuator board is sending a signal to open valve 43. This occurs every two minutes for several seconds. When V43= "1" is there flow from valve 43?

Yes Place the tubing back onto valve 43, REMOVE the clamp, and see CP- 5.0.0

No Leave the machine in RINSE. A problem is indicated with **VALVE 43**, the actuator board or the actuator cable. **NOTE** this and see CHECKING VALVES (page 28).



HYDRAULICS, TOP VIEW

CP- 5.0.0 CHECK VALVE 29

a) With the machine in RINSE, clamp the clear tubing at valve 29's input nozzle as close to the valve as possible (see diagram above) and then remove the tubing from the valve.

b) Fill a syringe with water. Using the same size tubing from valve 29 attach the syringe to valve 29's input nozzle.

c) From debug screen 20, when V29 = "1" the actuator board is sending a signal to open valve 29. This occurs ONLY for a few seconds every two minutes so be ready! When V29= "1" are you able to push water through the valve with the syringe?

Yes If flow errors continue an intermittent bad dialysate pressure transducer may be indicated or a bad deaeration pump head may be indicated.

No Leave the machine in RINSE. A problem is indicated with **VALVE 29**, the actuator cable or the actuator board. **NOTE** this and see CHECKING VALVES (page 28).

CHECKING VALVES

a) Proceed ONLY with the NOTED valve. Unplug the valve from its distribution board position (see table below) and check for bent, broken or corroded male pins.

b) From the indicated program mode (see table below) carefully measure dc voltage, inside the distribution board, between male pins 1 and 5 (top and bottom). Follow the instructions given.

VALVE	DISTRIBUTION POSITION	PROGRAM MODE	GOOD	BAD = LESS THAN 20 VDC
24	V24, DIAL-V1	RINSE	[1]Pulsing on and off, see CV- 1.0.0	Two possibilities: 1) [2]Bad actuator cable 2) Bad actuator board
41 (27)	V27	DIALYSIS	22 to 26 vdc, see CV- 1.0.0	Two possibilities: 1) [2]Bad actuator cable 2) Bad actuator board
39	V39, DEAR-V	RINSE	22 to 26 vdc, see CV- 1.0.0	Two possibilities: 1) [2]Bad actuator cable 2) Bad actuator board
29	V29, REC-V	RINSE	22 to 26 vdc ONLY when debug screen 20, V29 = 1, see CV- 1.0.0	Two possibilities: 1) [2]Bad actuator cable 2) Bad actuator board
43	V43	RINSE	22 to 26 vdc ONLY when debug screen 20, V43 = 1, see CV- 1.0.0	Two possibilities: 1) [2]Bad actuator cable 2) Bad actuator board

[1] In RINSE, voltage to valve 24 'pulses' on and off from between 26 to 22 vdc (on) to less than 2 vdc.

[2] The actuator cable can be checked for continuity. **NOTE** the specific **VALVE** whose connection you are checking and see CHECKING THE ACTUATOR CABLE (page 72).

CV- 1.0.0 CHECK FOR AN OPEN

Open the plastic cover of the female distribution board connector. Leaving it unplugged measure resistance between pins 1 and 5 (wires connected) inside the female connector. 50 to 80 Ω?

Yes The valve is bad or possibly restricted.

No Leave the connector unplugged for now and see CV- 1.0.1

CV- 1.0.1 CHECK SOLENOID RESISTANCE

A two-wire harness runs from the female connector and plugs onto two terminals at the valve's solenoid. See diagrams (page 32) to locate valves. Leaving the female connector unplugged measure resistance between the male solenoid terminals. 50 to 80 Ω ?

Yes The harness between the distribution board and the solenoid is bad.

No Replace the valve.

TROUBLESHOOTING VALVES

a) Proceed **ONLY** with the **NOTED** valve. Unplug the valve at the distribution board (see table below) and check for bent, broken or corroded male pins.

b) From the indicated program mode (see table below) measure voltage, inside the distribution board, between male pins 1 and 5 (top and bottom). Follow the instructions given.

VALVE	DISTRIBUTION POSITION	PROGRAM MODE	GOOD	BAD
25	V25, DIAL-V2	SELECT ANY PROGRAM	22 to 26 vdc, valve 25 is bad or possibly restricted	Less than 20 vdc, Bad actuator board
26	V26, BYPASS-V	RINSE	[1]Pulsing on and off, valve 26 is bad or possibly restricted	Less than 20 vdc, Bad actuator board
30	V30, DRAIN-V	DIALYZE	22 to 26 vdc, valve 30 is bad or possibly restricted	Less than 20 vdc, Bad actuator board

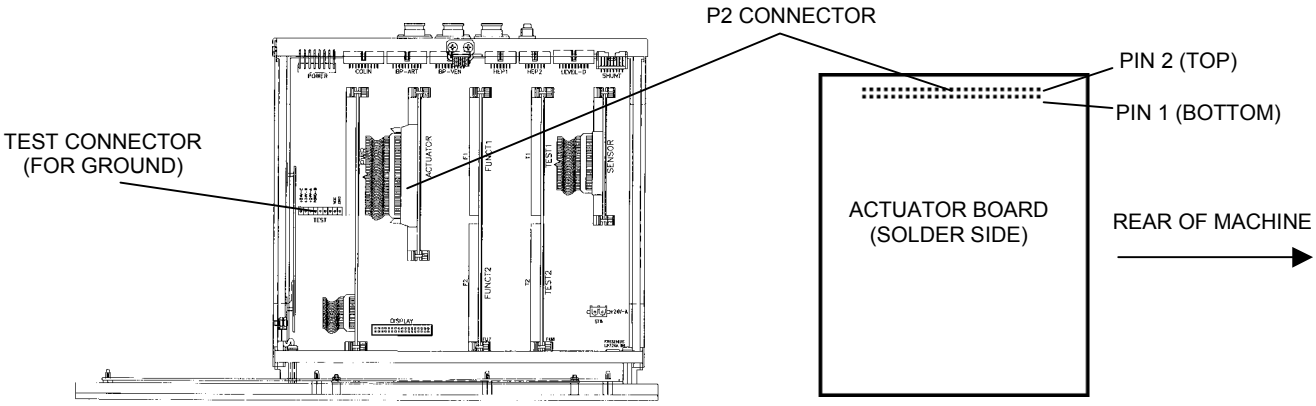
[1] In RINSE, voltage to valve 26 'pulses' on and off from between 26 to 22 vdc (on) to less than 2 vdc.

TROUBLESHOOTING VALVE ERRORS

Proceed **ONLY** with the **NOTED** valve(s).

a) Turn the power off and clip a ground lead onto PGND-B at the TEST connector (see diagram, below).

b) At the top of the actuator board (see diagram below) there is a large 50-pin connector called the 'P2'. A ribbon cable plugs in here that runs to the distribution board.



CARD CAGE

c) Measure resistance at the solder (back) side pins of the P2 connector as directed in the table. See **TABLE 1** to check VALVES 30, 26 and 25 (as prompted from steps 1 or 3, F- 5.0.1). See **TABLE 2** to check the **BALANCING CHAMBER VALVES** (as prompted from step 2, F- 5.0.1). Follow directions given:

TABLE 1 (from step 1 or 3, F- 5.0.1) TO CHECK VALVES 30, 26 AND 25

VALVE	PIN	P2 PIN LOCATION	GOOD = BETWEEN 50 AND 80 Ω	BAD = LESS THAN 50 OR GREATER THAN 80 Ω (NOTE M Ω = MEG OHMS)
30	35	bottom row, 8 pins from front	Check also valve 26	Greater than 80, See VE- 1.0.0 Less than 50, See VE- 1.0.4
26	31	bottom row, 10 pins from front	See VE- 1.0.2	Greater than 80, See VE- 1.0.0 Less than 50, See VE- 1.0.4
25	30	top row, 11 pins from front	See VE- 1.0.2	Greater than 80, See VE- 1.0.0 Less than 50, See VE- 1.0.4

TABLE 2 (from step 2, F- 5.0.1) TO CHECK BALANCING CHAMBER VALVES

VALVE	PIN	P2 PIN LOCATION	GOOD = BETWEEN 50 AND 80 Ω	BAD = LESS THAN 50 OR GREATER THAN 80 Ω (NOTE M Ω = MEG OHMS)
31	36	top row, 8 pins from front	Check also valve 32	Greater than 80, See VE- 1.0.0 Less than 50, See VE- 1.0.4
32	37	bottom row, 7 pins from front	Check also valve 33	Greater than 80, See VE- 1.0.0 Less than 50, See VE- 1.0.4
33	38	top row, 7 pins from front	Check also valve 34	Greater than 80, See VE- 1.0.0 Less than 50, See VE- 1.0.4
34	39	bottom row, 6 pins from front	Check also valve 35	Greater than 80, See VE- 1.0.0 Less than 50, See VE- 1.0.4
35	40	top row, 6 pins from front	Check also valve 36	Greater than 80, See VE- 1.0.0 Less than 50, See VE- 1.0.4
36	41	bottom row, 5 pins from front	Check also valve 37	Greater than 80, See VE- 1.0.0 Less than 50, See VE- 1.0.4
37	42	top row, 5 pins from front	Check also valve 38	Greater than 80, See VE- 1.0.0 Less than 50, See VE- 1.0.4
38	43	bottom row, 4 pins from front	See VE- 1.0.2	Greater than 80, See VE- 1.0.0 Less than 50, See VE- 1.0.4

VE- 1.0.0 CHECK FOR AN 'OPEN' CIRCUIT

Unplug the **NOTED** valve from the distribution board (for example, valve 36 plugs into position V36) and open the plastic cover from the female connector. Leaving the female connector unplugged measure between pins 1 and 5 (where the wires are soldered) inside the female connector. Between 50 and 80 Ω?

Yes See VE- 1.0.4

No See VE- 1.0.3

VE- 1.0.2 CHECK ACTUATOR BOARD CABLE

Unplug the actuator board cable from both ends (the cable terminates at distribution board's ACTUATOR connector): a) Using a flashlight check the male side of each connector for (white) corrosion. Check also for bent or broken pins; b) Check the female side of both connectors for (white) corrosion. If ok replace the actuator cable.

VE- 1.0.3 CHECK VALVE SOLENOID

Each valve has a two-pin wiring harness that runs from the distribution board and terminates at its solenoid where it plugs onto *two male terminals (see the diagrams (next page) to locate the **NOTED** valve). Unplug the harness and measure between the male solenoid terminals. Between 50 and 80 Ω?

Yes The wiring harness is bad.

No Replace the valve.

* Some harnesses may wire directly into the solenoid. If so replace the valve.

VE- 1.0.4 CHECK ACTUATOR BOARD CABLE

Unplug the actuator cable from the distribution board (ACTUATOR connector). Leave the actuator board side plugged in. Measure again at the **NOTED** valve's actuator board P2 connector pin (as instructed above). Greater than 2 MΩ now?

Yes See VE- 1.0.5

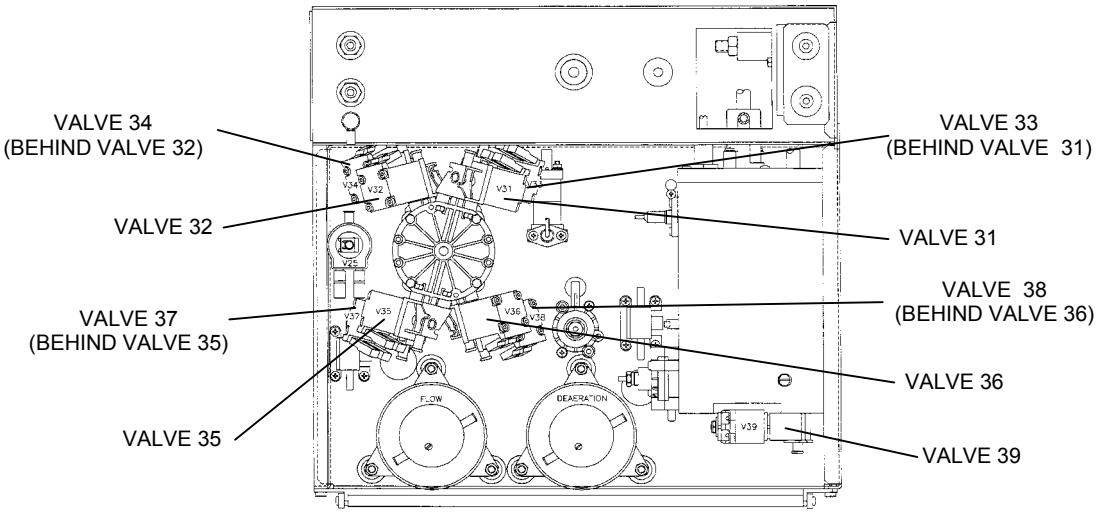
No Unplug the actuator cable from the actuator board itself and measure again at the **NOTED** valve's actuator board P2 connector pin (as instructed above). If less than 2 MΩ replace the actuator board (shorted driver) otherwise proceed to VE- 1.0.5

VE- 1.0.5 CHECK ACTUATOR CONNECTOR PINS/ VALVE HARNESS

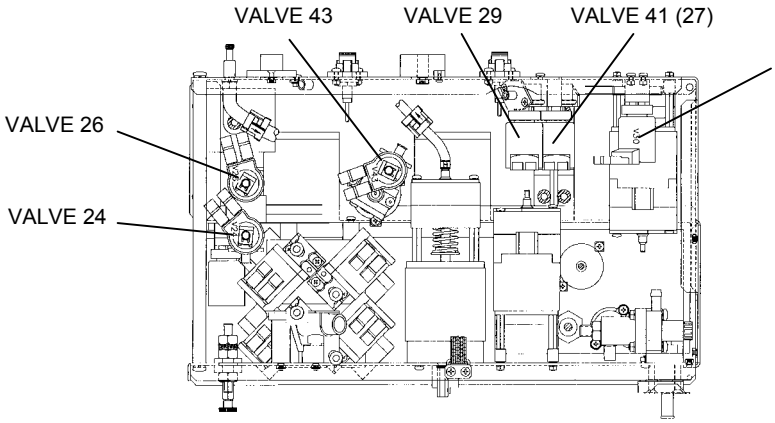
a) Using a flashlight check for bent or (white) corroded male pins at each connector (both at the actuator board and distribution board side).

b) Check the 2-pin wiring harness that runs from the NOTED valve's solenoid to the distribution board. If damage is seen replace the harness.

c) Plug all cables back in and place the machine back into dialyze mode. If the VALVE ERROR continues there are two possibilities: 1) Bad actuator board; 2) Bad actuator cable.



HYDRAULICS, REAR VIEW



HYDRAULICS, TOP VIEW

SECTION 4 - TEMPERATURE PROBLEMS

CAREFULLY read the list of symptoms and proceed with the one that best describes the problem:

1. TEMP display remains at 33°C; a) Check that the heater breaker switch is on i.e "1" is pushed in (see diagram A, page 5); b) If the problem is still present after 10 minutes see T- 1.0.0

2. TEMP display increases to about 40°C, falls and then rises again. See T- 4.0.0

3. You are currently attempting HEATER CONTROL CALIBRATION but it does not calibrate properly: a) Check that the heater breaker switch is on i.e."1" is pushed in (see diagram A, page 5); b) If 'measured' temperature increases to 40°C (or greater) causing no flow through the external flow indicator RETURN to DIALYZE mode and see T- 4.0.0; c) If parts a and b do not describe the problem RETURN to DIALYZE mode and see T- 1.0.0.

4. The machine is currently in HEAT DISINFECT and:

    - TEMPERATURE remains at 33°C; a) Check that the heater breaker switch is on i.e."1" is pushed in (see diagram A, page 5); b) If the problem is still present after 10 minutes RETURN to DIALYZE mode and see T- 1.0.0

    - TEMPERATURE fails to reach 80°C but is greater than 33°C. See T- 3.0.0

    - TEMPERATURE increases to about 90°C, falls and then rises again. See T- 4.0.0

5. TEMP display and measured 'actual' temperature are not the same. Watch VERY carefully for 10 minutes to assure that the TEMP display is remaining stable. If so see T- 5.0.0

T- 1.0.0 CHECK FOR NO WATER, FLOW ERROR AND FILLING PROGRAM

a) Call up debug screen 5 and carefully watch !WATER and FLWERR for two minutes. If either goes to "1" (intermittently or constant) see FLOW ERRORS IN DIALYZE MODE (page 6).

b) Call up debug screen 7. If FILACT = "1" a FILLING PROGRAM is present. Do **NOT** troubleshoot TEMPERATURE PROBLEMS with a FILLING PROGRAM present. If FILACT = "0" proceed to T- 1.0.1

T- 1.0.1 CHECK TEMP SET POINT

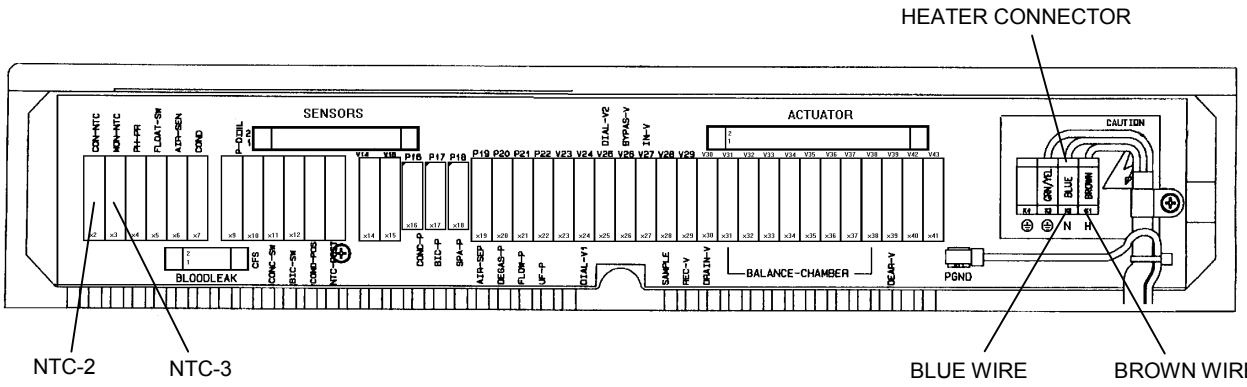
From the main DIALYSIS screen use the arrow keypads to select TEMP and push the SET keypad to make a "?" appear. The indicated TEMP value is the current 'set point'. If necessary use the arrows keypads to adjust 'set point' and push the SET keypad again. Allow 10 minutes for stabilization. If adjustment is not necessary or if the problem is still present see T- 1.0.2.

T- 1.0.2 CHECK HEATER VOLTAGE

CAUTION 120 VAC!. Measure ac voltage, between the **BLUE** and **BROWN** heater wires at the distribution board's heater connector (see diagram, next page). Voltage may be 'pulsing' causing the meter to O.L. intermittently (this is normal). Greater than 90 vac?

Yes See T- 1.0.3

No See T- 2.0.0



T- 1.0.3 CHECK HEATER

IMPORTANT turn the POWER OFF. Measure RESISTANCE between the **BLUE** and **BROWN** heater wires (see diagram above). Between 10 and 13 Ω?

Yes See T- 5.0.0 (page 43).

No Replace the heater.

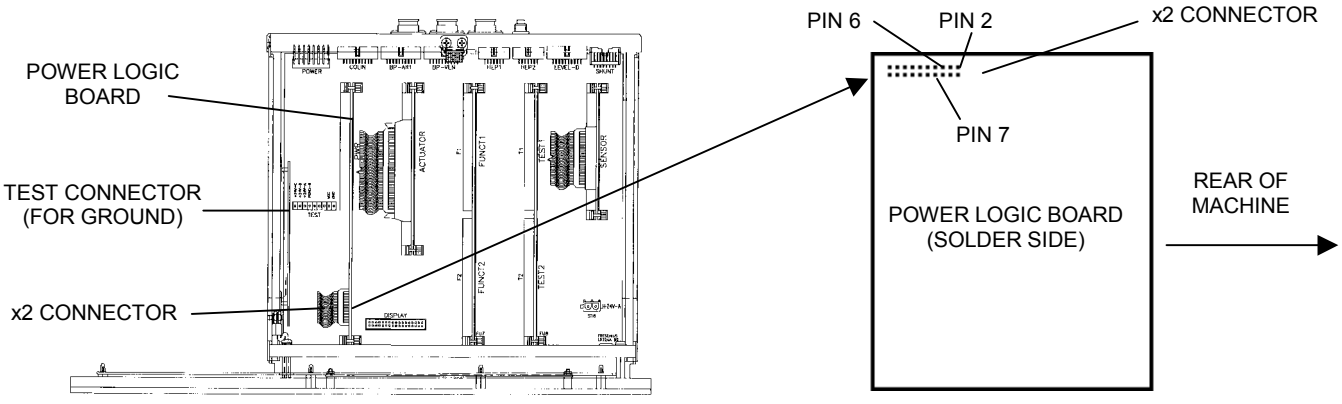
T- 2.0.0 CHECK LOGIC SIGNALS

CAUTION During these procedures dc voltages are measured at the solder (back) side of the POWER LOGIC BOARD'S x2 connector. The pins are very close to each other and 'shorting' them together with a meter probe can damage the board. It is RECOMMENDED that you use TP80 (non-standard) meter probes together with the slip-on cap.

a) Turn the power off and clip a ground lead onto SGND at the TEST connector (see diagram below).

b) At the top, very front of the POWER LOGIC BOARD is the 20-pin 'x2' connector (see diagram below). A ribbon cable terminates here that runs into the upper power supply. The solder side pins are arranged in two rows. Top are the even numbered, bottom are odd.

c) Turn the power on and go to DIALYZE MODE by pushing the SET twice button. Measure at the pins specified in the LOGIC SIGNALS table (next page) and follow the directions given:



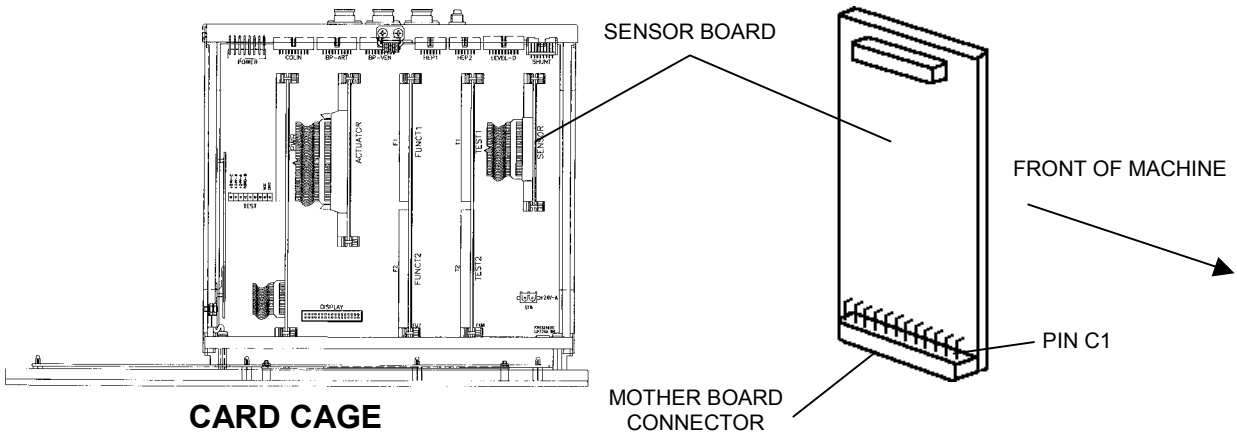
CARD CAGE

LOGIC SIGNALS

PIN	x2 LOCATION	GOOD SIGNAL (vdc)	BAD SIGNAL (vdc)
6	top row, three pins from the rear	9.6 or greater, measure at x2, pin 7	3.6 or lower, see T- 2.1.0
7	bottom row, four pins from the rear	4 or greater, measure at x2, pin 2	1.5 or lower, see T- 2.2.0
2	top row, first pin from the rear	2 or lower, see T- 2.4.0	22 to 26, see T- 2.3.0

T- 2.1.0 CHECK SENSOR BOARD SIGNAL

a) At the very BOTTOM, left hand side (component side) of the SENSOR board is its motherboard connector (see CARD CAGE diagram below). A row of pins extend horizontally, turns 90 degrees downward and runs into the connector. This is the "C row", numbered 1 through 32 (from front-to-rear).



CARD CAGE

b) Using a STANDARD meter probe (do NOT use the non-standard probe) CAREFULLY measure voltage at pin C1 (very FRONT motherboard pin). High (9.6 vdc or greater) or low (less than 3.6 vdc)?

High See T- 2.1.2

Low See T- 2.1.1

T- 2.1.1 CHECK POWER LOGIC BOARD

a) Turn the power off and swap in a power logic board.

b) Turn the power on and measure again at the power logic board's x2 connector, pin 6. High (9.6 vdc or greater) or low (3.6 vdc of lower)?

High The previous power logic board is bad.

Low See T- 2.5.0 (the previous power logic board is good).

T- 2.1.2 CHECK NTC-2

Unplug NTC-2 from the distribution board (FIRST! position on left, x2 CON-NTC). Does pin C1 go low?

Yes Replace NTC-2.

No See T- 2.1.3

T- 2.1.3 CHECK NTC-2 CIRCUIT

a) Turn the power off and unplug both ends of the 34-pin sensor board cable. Check for bent, broken or corroded male pins at each connector.

b) Plug the cable back in and swap a power logic board.

c) Turn the power back on and measure again at the sensor board's motherboard pin C1. High (9.6 vdc or greater) or low (3.6 vdc or lower)?

High Replace the sensor board (the previous power logic board is good).

Low The previous power logic board is bad

T- 2.2.0 CHECK FOR FLOW ERRORS

Call up debug screen 5. Is FLWERR = "1"?

Yes See FLOW ERRORS IN DIALYZE MODE (page 6).

No See T- 2.2.1

T- 2.2.1 CHECK ACTUATOR BOARD

a) Turn the power off and swap in an actuator board.

b) Turn the power on and go to DIALYZE MODE by pushing the SET button twice.

c) Measure again at the power logic board's x2 connector, pin 7. High (greater than 4 vdc) or low (less than 1.5 vdc)?

High The previous actuator board is bad.

Low See T- 2.5.0 (the previous actuator board is good).

T- 2.3.0 CHECK POWER LOGIC/FUNCTIONAL BOARD

a) Turn the power off and swap in a power logic board.

b) Turn the power on and go to DIALYZE MODE by pushing the SET button twice. Wait 15 seconds.

c) Measure again at the solder side of the power logic board's x2 connector, pin 2 (top row, first pin from rear). Less than 2 vdc now?

Yes The previous power logic board was bad.

No Replace the functional board (the previous power logic board is good).

T- 2.4.0 CHECK HEATER RELAY

a) Turn the power off and then back on. Allow the SELECT PROGRAM screen to come up. IMPORTANT! Do NOT enter dialyze mode.

b) From SELECT PROGRAM measure again at the solder side of the power logic board's x2 connector, pin 2 (top row, first pin from rear). Approximately 24 ± 2.0 vdc?

Yes See T- 2.6.0

No See T- 2.5.0

T- 2.5.0 CHECK POWER LOGIC CABLE/POWER CONTROL BOARD

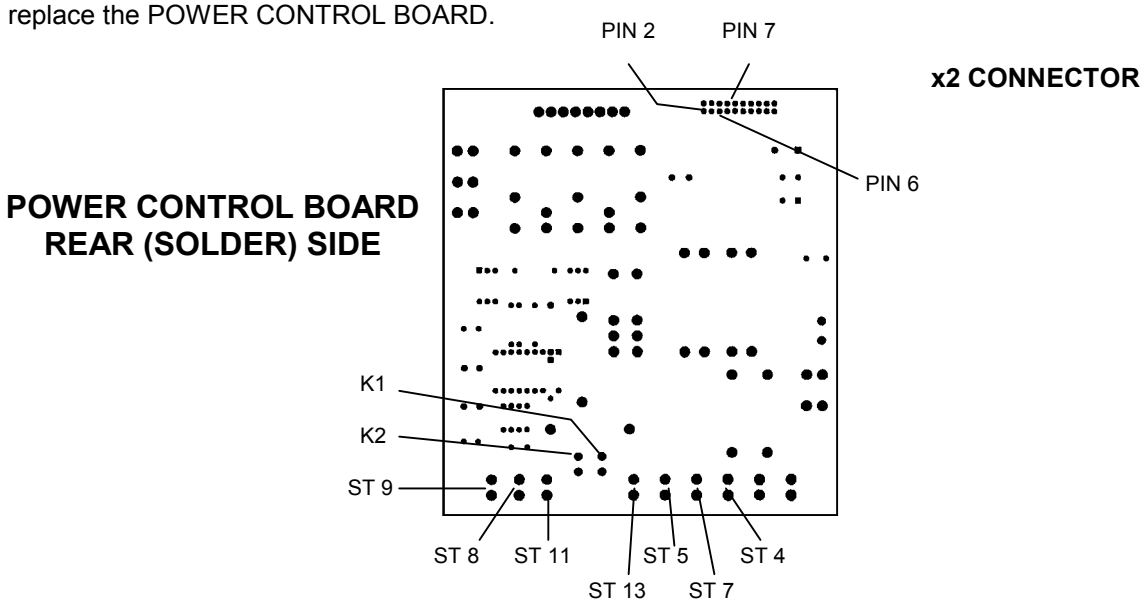
Either the 20-pin power logic board cable or the power control board is bad.

a) Turn the power off and UNPLUG the machine. CAUTION, 120 VAC IF NOT UNPLUGGED!

b) Slide the upper power supply (see diagram A, page 5) away from the cabinet. Inside is the power control board where the 20-pin 'x2' cable terminates. Check that the cable is plugged in properly.

c) Unmount the power control board from the plastic clips to allow easy access to the rear (solder) side (see diagram below).

d) Measure resistance from pin 2, at the POWER LOGIC BOARD'S end of the cable (x2 connector, top row, first pin from rear), to pin 2 at the POWER CONTROL BOARD'S end. If the cable is good (10 Ω or less) replace the POWER CONTROL BOARD.



T- 2.6.0 CHECK POWER LOGIC BOARD CABLE

a) Turn the power off and UNPLUG the machine. CAUTION, 120 VAC IF NOT UNPLUGGED!

b) Slide the upper power supply (see diagram A, page 5) away from the cabinet. Inside is the power control board where the 20-pin 'x2' cable terminates. Check that the cable is plugged in properly.

c) Unmount the power control board from the plastic clips to allow easy access to the rear (solder) side (see diagram above). Measure resistance from (two measurements):

1) Pin 6, at the POWER LOGIC BOARD'S end of the cable (x2 connector, top row, three pins from rear), to pin 6 at the POWER CONTROL BOARD'S end (see diagram above).

2) Pin 7, at the POWER LOGIC BOARD'S end of the cable (x2 connector, bottom row, four pins from rear), to pin 7 at the POWER CONTROL BOARD'S end (see diagram above).

d) If the cable is good (10Ω or less) see T- 2.6.1

T- 2.6.1 CHECK TRIAC VOLTAGE DROP

a) Set meter to ac volts and CLIP the leads, onto the SOLDER side of the power control board, at connectors ST 8 and ST 11 (see diagram, previous page).

b) Plug the machine in. CAUTION, 120 VAC NOW PRESENT!

c) Turn the power on and go to DIALYZE MODE by pushing the SET button twice. Wait 15 seconds. Greater than 90 vac across the triac?

Yes See T- 2.6.2

No See T- 2.7.0

T- 2.6.2 CHECK TRIAC GATE SIGNAL

a) Turn the POWER OFF and UNPLUG the machine.

b) CLIP the meter leads, onto the SOLDER side of the power control board at connector K 2 and terminal ST9 (see diagram, previous page).

c) Plug the machine in. CAUTION, 120 VAC NOW PRESENT!

d) Turn the power on and go to DIALYZE MODE by pushing the SET button twice. Wait 15 seconds. 90 vac or greater?

Yes Bad power control board.

No Bad triac (trace the orange wire from connector ST 9 down to the triac).

T- 2.7.0 CHECK HEATER CONNECTIONS

a) Turn the POWER OFF and UNPLUG the machine.

b) Measure resistance, on the SOLDER side of the power control board, between connectors K 2 and K 1 (see diagram, previous page). Less than 20 Ω (ohms)?

Yes See T- 2.7.1

No Check for an 'open' circuit to the heater.

T- 2.7.1 CHECK HEATER BREAKER

a) Referring to the diagram on the previous page measure resistance, on the SOLDER side of the power control board, BETWEEN connectors:

1) ST 7 and ST 13

2) ST 4 and ST 5

b) Both less than 30 ohms?

Yes See T- 2.7.2

No Replace the heater breaker. It is 'open'.

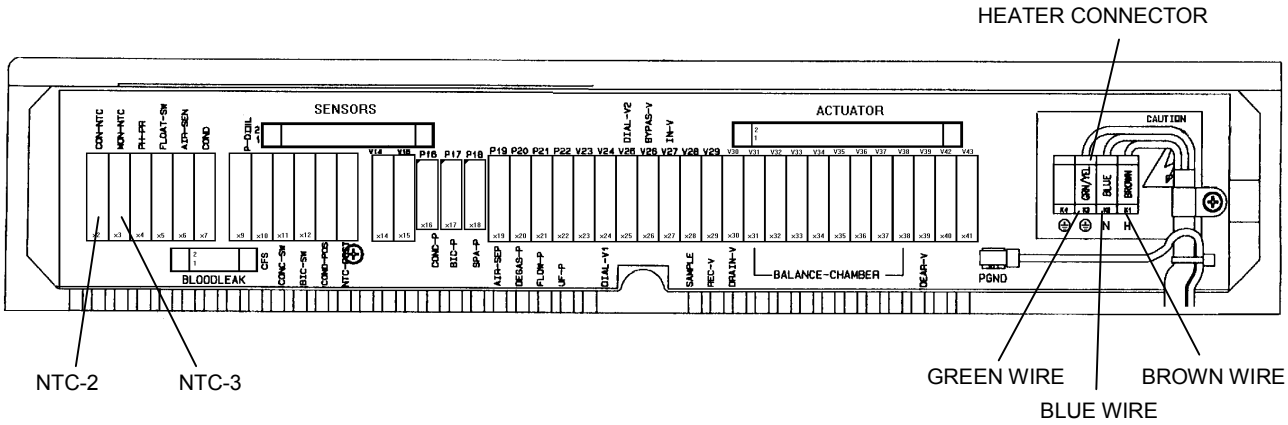
T- 2.7.2 CHECK HEATER VOLTAGE

a) Turn the power on and go to DIALYZE MODE by pushing the SET button twice.

b) CAUTION 120 VAC!. Measure ac voltage, between the GREEN and BROWN heater wires at the distribution board's heater connector (see diagram below). Greater than 90 vac?

Yes Everything is checking good. If the temperature problem is still present return to T- 1.0.0 and proceed carefully.

No Replace the power control board (inside upper power supply).



T- 3.0.0 CHECK HEATER

a) Turn the heater breaker switch off (see diagram A, page 5) and allow the TEMP display to reach 33°C.

b) Turn the POWER OFF and measure RESISTANCE, between the BROWN and BLUE heater wires at the distribution board's heater connector (see diagram above). Between 10 and 13 Ω?

Yes Turn the heater breaker switch back on and see T- 3.0.1

No Replace the heater

T- 3.0.1 CHECK TEMPERATURE DISPLAY

a) Place the machine in DIALYZE MODE (this procedure does not work in HEAT DISINFECT).

b) Plug the 40°C Fresenius temperature 'dummy' connector into NTC-3's distribution board position (MON-NTC, SECOND! position from the left). CAUTION! Be careful to plug into the correct position.

c) Does the TEMP display (main screen) read between 38 and 42°C?

Yes See T- 3.0.2

No See T- 6.0.0 (page 43).

T- 3.0.2 CHECK RECIRCULATION

Return to HEAT DISINFECT and call up debug screen 20. When V29 = "1" the actuator board is opening recirc valve 29. Wait until V29 = "1" CONSTANTLY. Is there flow to the drain?

Yes See T- 3.0.3

No Note that NTC-2 OR NTC-3 may be a problem and see T- 9.0.0 (page 44).

T- 3.0.3 CHECK VALVE 30

Unplug valve 30 from the distribution board (position V30). Does flow to the drain stop?

Yes Replace the actuator board.

No Replace valve 30.

T- 4.0.0 CHECK SENSOR BOARD SIGNAL

a) Turn the power off and clip a ground lead onto SGND at the TEST connector (see diagram below).

NOTE: Troubleshooting this symptom **CANNOT** be done in HEAT DISINFECT. If currently in HEAT DISINFECT return to **DIALYZE MODE**.

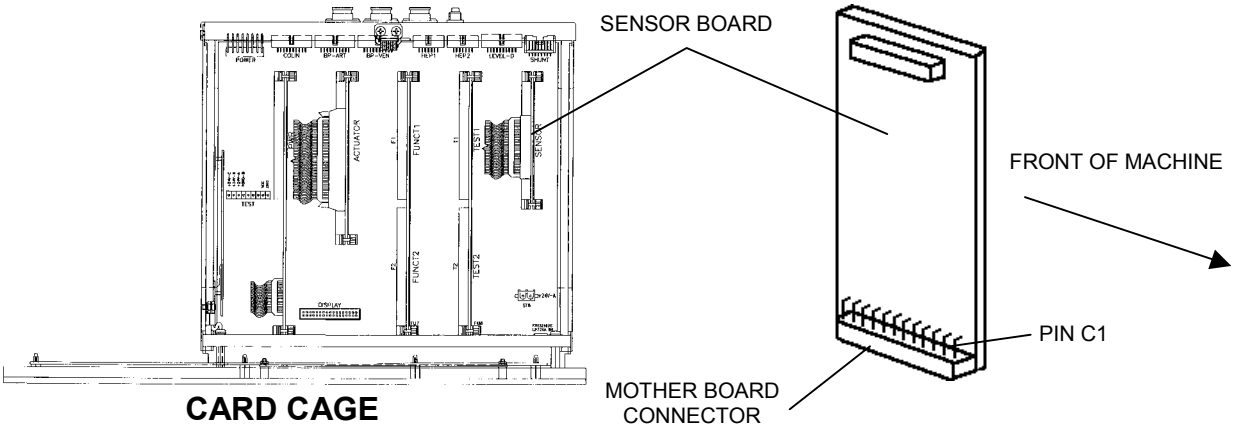
b) Plug the 80°C Fresenius test (temperature) 'dummy connector' into NTC-2's distribution board position (FIRST! position on the left, CON-NTC). CAUTION! Be careful to plug in correctly!

c) At the very BOTTOM, left hand side (component side), of the SENSOR board is its motherboard connector (see CARD CAGE diagram below). A row of pins extend horizontally, turns 90 degrees downward, and runs into the connector. This is the "C row", numbered 1 through 32 (from front-to-rear).

d) Turn the power on. Using a STANDARD meter probe (do not use the non-standard probe) CAREFULLY measure dc voltage at pin C1 (very FRONT motherboard pin). High (9.6 vdc or greater) or low (less than 3.6 vdc)?

High Leave the 'dummy' in for now and see T- 4.1.0

Low Note that NTC-2 may be a problem and see T- 9.0.0 (page 44).

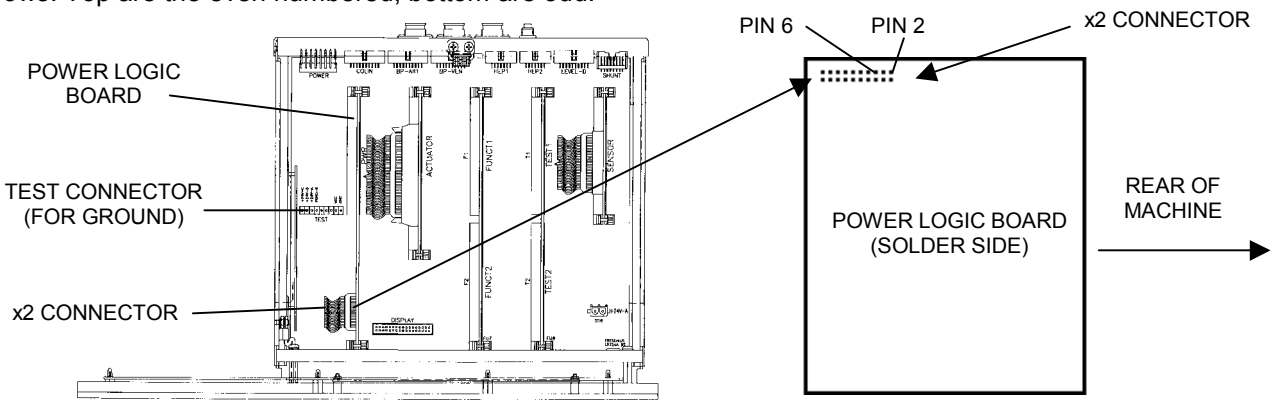


CARD CAGE

T- 4.1.0 CHECK LOGIC SIGNAL

CAUTION During these procedures dc voltages are measured at the solder (back) side of the POWER LOGIC BOARD'S x2 connector. The pins are very close to each other and 'shorting' them together with a meter probe can damage the board. It is RECOMMENDED that you use TP80 (non-standard) meter probes together with the slip-on cap.

a) At the top, very front of the POWER LOGIC BOARD is the 20-pin 'x2' connector (see diagram below). A ribbon cable terminates here that runs into the upper power supply. The solder side pins are arranged in two rows. Top are the even numbered, bottom are odd.



CARD CAGE

b) Turn the power on and measure at the solder side of the x2 connector, pin 6 (top row, 3 pins from rear). High (greater than 9.6 vdc) or low (less than 3.6 vdc)?

High See T- 4.2.0

Low Watch the TEMP display (main screen) for 8 minutes (as necessary). Drop to 33°C?

Yes Replace NTC- 2

No Continues to increase to about 40°C (or greater), see T- 4.3.0.

T- 4.2.0 CHECK POWER LOGIC BOARD

a) Turn the power off and swap the power logic board.

b) Turn the power back on and go to DIALYZE MODE. Watch for 10 minutes. If TEMP continues to increase to about 40°C replace the power control board (inside the upper power supply). The previous power logic board is good.

T- 4.3.0 CHECK FOR A SHORTED TRIAC

a) Turn the power off and UNPLUG the machine. CAUTION, 120 VAC IF NOT UNPLUGGED!

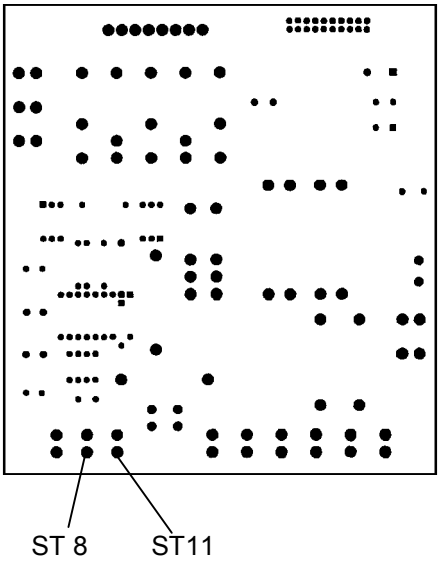
b) Unmount the upper power supply from the cabinet (see diagram A, page 5). Inside is the power control board which is mounted to the case with plastic clips. Unmount the board from the clips to allow easier access to the back (solder) side of the board.

c) Measure resistance, on the solder side of the power control board, between connectors ST 8 and ST 11 (see SOLDER SIDE diagram, next page). Greater than 3 Meg Ω?

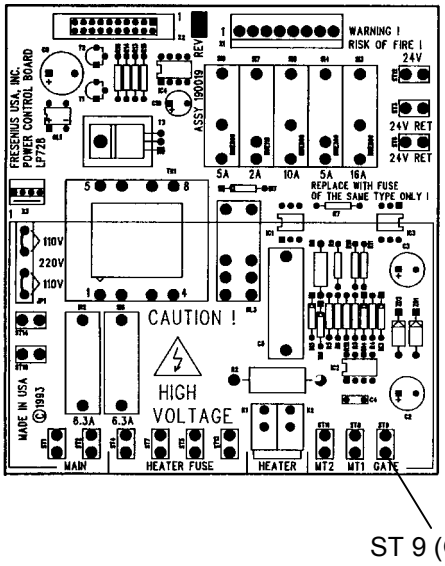
Yes See T- 4.4.0

No Replace the triac (trace the blue, brown and orange wires to it).

POWER CONTROL BOARD SOLDER SIDE



POWER CONTROL BOARD FRONT SIDE



T- 4.4.0 CHECK TEMP CALIBRATION

a) Turn the power off and place the machine in SERVICE/CALIBRATION. Connect a temperature meter into the dialysate lines to measure 'actual' temperature. CAUTION Fluid may be hot!

b) Turn the power back on and enter HEAT TEMP CONTROL. Lower the DAC value to "0".

c) Watch 'actual' temperature for 8 minutes. Continue to increase to high?

Yes Leave the temperature meter in line for now and see T- 4.5.0

No Plug NTC-2 back into the distribution board (FIRST! position on the left, CON-NTC) and calibrate HEATER TEMP CONTROL.

T- 4.5.0 REMOVE TRIAC'S GATE SIGNAL

a) Turn the power off and UNPLUG the machine. CAUTION, 120 VAC IF NOT UNPLUGGED!

b) Unplug the female terminal connector from the power control board's (GATE) terminal ST 9 (see FRONT SIDE diagram above).

c) Wrap BLACK tape around the female terminal connector. CAUTION! The connector is 'live' (120 vac) when the power is on. Damage to the machine or electrocution may occur if not wrapped.

d) Plug the machine in (CAUTION, 120 VAC NOW PRESENT!). Turn the power on and enter CALIBRATION/HEAT TEMP CONTROL.

e) Lower the DAC value to "0" and watch 'actual' temperature for 8 minutes. Continue to increase to high?

Yes Replace the triac and calibrate HEATER TEMP CONTROL.

No Replace the power control board and calibrate HEATER TEMP CONTROL.

T- 5.0.0 CHECK TEMP DISPLAY

Plug the 40°C Fresenius test (temperature) 'dummy connector' into NTC-3's position (SECOND! position from the left, MON-NTC). CAUTION! Plug in correctly. Does the TEMP display (main screen) read between 38 and 42°C?

Yes Note that NTC- 3 may be a problem and see T- 9.0.0 (page 44).

No See T- 6.0.0

T- 6.0.0 CHECK DEBUG TEMPERATURE VALUES

a) With the 41°C (5.11KΩ) connector plugged in call up debug screen 9 and note TEMP. Good = 8.5 (+/- 1.6) vdc.

b) Call up debug 11 and note ATEM. Good = 7.7 (+/- 0.3) vdc. Refer to DEBUG table below.

DEBUG TABLE

DEBUG 9, TEMP	DEBUG 11, ATEM	RESPONSE
GOOD	GOOD	See T- 7.0.0
GOOD	BAD	Replace the actuator board
BAD	GOOD	Replace the sensor board
BAD	BAD	See T- 8.0.0

T- 7.0.0 CALIBRATE TEMP

a) Plug NTC-3 back into distribution board (**SECOND!** position from left, x3 MON-NTC). CAUTION! Be sure to plug in correctly.

b) Calibrate HEATER CONTROL per CALIBRATION PROCEDURES, section 2.5. If not successful note that either NTC- 2 **or** NTC- 3 may be a problem and see T- 9.0.0 (page 44).

T- 8.0.0 CHECK TEST BOARD

a) Turn the machine off and swap in a test board. **NOTE**: An alternative is to remove IC 4 from the test board. The machine runs ok but will not pass tests.

b) Turn the power on and enter dialyze mode. With the 41°C (5.11KΩ) dummy connector plugged in call up debug screen 9. TEMP = 8.5 (+/- 1.6) vdc?

Yes The previous test board (or IC 4, test board) is bad.

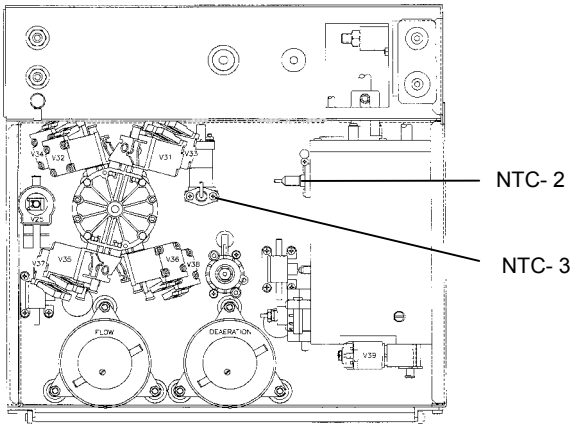
No Four possibilities: 1) *Bad sensor board cable; 2) HEAT TEMP CONTROL not calibrated accurately; 3) Bad sensor board; 4) Bad functional board.

* The sensor cable can be checked for continuity. Note that you are checking **NTC-2** and **NTC-3** connections and see CHECKING THE SENSOR BOARD CABLE (page 74).

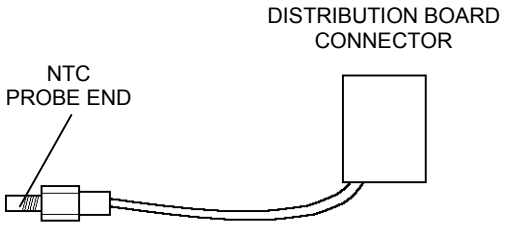
T- 9.0.0 CHECK NTC RESISTANCE

Proceed **ONLY** with the NTC(s) as noted above.

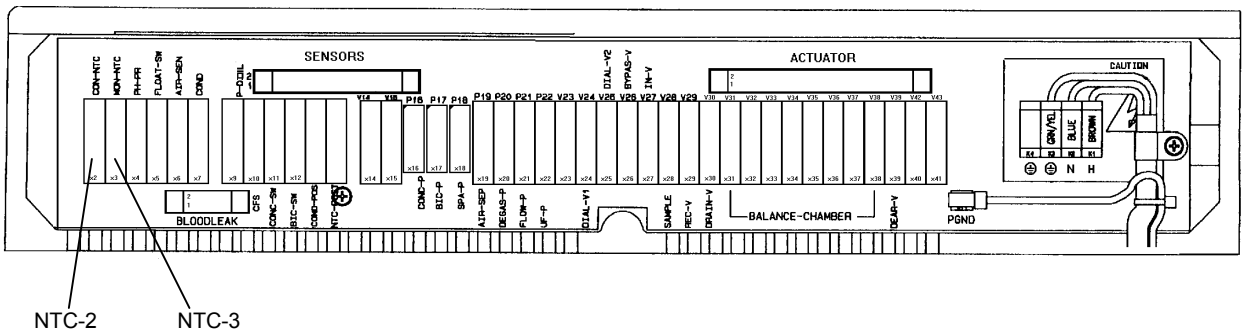
a) Turn the **POWER OFF** and remove the NTC(s) from the respective hydraulic location (see diagram below). This reveals the 'probe' end.



HYDRAULICS, REAR VIEW



b) Unplug the NTC from its distribution board connector (see diagram below). Check, inside the distribution board, for bent, broken, or corroded **male** pins.



c) **VERY CAREFULLY**! (thin wires inside!) open the plastic cover from the NTC's female connector. Clip meter leads onto pins 1 and 3 (top and middle, typically green and white wires attached).

d) Draw water, between 36 and 38°C, into a styrofoam cup. Water temperature should be ACCURATELY measured with an **external** thermometer.

e) Drop the 'probe' end into the water and allow the resistance value to stabilize. Refer to the NTC RESISTANCE table (page 45). Replace any NTC that checks bad and calibrate HEAT TEMP CONTROL.

f) If NTC(s) check good there are four possibilities: 1) *Bad sensor board cable; 2) HEAT TEMP CONTROL not calibrated accurately; 3) Bad sensor board; 4) Bad functional board.

* The sensor cable can be checked for continuity. Note that you are checking **NTC-2** and **NTC-3** connections and see CHECKING THE SENSOR BOARD CABLE (page 74).

NTC RESISTANCE

Temperature (°C)	Low Resistance (KΩ)	Nominal Resistance (KΩ)	High Resistance (KΩ)
36.0	6.142	6.267	6.392
36.1	6.117	6.242	6.367
36.2	6.092	6.217	6.342
36.3	6.067	6.192	6.317
36.4	6.042	6.167	6.292
36.5	6.017	6.142	6.267
36.6	5.992	6.117	6.242
36.7	5.967	6.092	6.217
36.8	5.942	6.067	6.192
36.9	5.917	6.042	6.167
37.0	5.892	6.017	6.142
37.1	5.868	5.993	6.118
37.2	5.844	5.969	6.094
37.3	5.820	5.945	6.070
37.4	5.796	5.921	6.046
37.5	5.772	5.897	6.022
37.6	5.748	5.873	5.998
37.7	5.724	5.849	5.974
37.8	5.700	5.825	5.950
37.9	5.676	5.801	5.926
38.0	5.652	5.777	5.902

SECTION 5 - CONDUCTIVITY PROBLEMS

CO- 1.0.0 CHECK CONCENTRATE

a) If other machines are experiencing the same symptoms there may be a problem with the concentrate batch. Use fresh bicarb.

b) From the VERIFY CONCENTRATE screen assure that the proper concentrate, Na and Bic levels are selected. If not this may be the problem.

c) Assure that the concentrate connectors are plugged into the proper concentrates. If all is ok proceed to CO- 1.0.1

CO- 1.0.1 CHECK FLOW/TEMPERATURE

a) Call up debug screen 5. If FLWERR = "1" a flow error is present. Do NOT troubleshoot CONDUCTIVITY PROBLEMS until flow errors are clear.

b) Push SET to return to the main screen. Assure TEMP is stable and within (+/-) 0.3 of unit standards. Do NOT troubleshoot CONDUCTIVITY PROBLEMS unless temperature is good.

c) If there are no flow errors or temperature problems proceed to CO- 1.0.2

CO- 1.0.2 CHECK FOR END OF STROKE (EOS) ERRORS

Call up debug screen 7. Is either NO EOS or ALWEOS ="1"?

Yes See CONCENTRATE PUMP END OF STROKE ERRORS (page 52).

No Proceed accordingly:

1) COND constantly low. See CO- 3.0.0

2) COND constantly high. See CO- 2.0.0

3) COND drifting from good to high. See CO- 2.0.0

4) COND rapidly bouncing from 10 to 17. See CO- 4.0.0 (page 48).

CO- 2.0.0 CHECK THE 'OUT OF BYPASS' HYDRAULIC CIRCUIT

Place the machine into RINSE and assure that the external flow indicator (75) is vertical. Is the' bob' (inside the indicator) rising?

Yes See CO- 7.0.0 (page 50)

No A flow problem is indicated. See F- 17.0.0 (page 15).

CO- 3.0.0 CHECK CONCENTRATE SELECTION

From the VERIFY CONCENTRATE screen is Bicarb or Acetate concentrate selected?

Bicarb See CO- 3.0.1

Acetate See CO- 3.0.2

CO- 3.0.1 CHECK BICARB STEPS

Call up debug screen 0. Is ABIC = "0"? IMPORTANT NOTE: If BIC also = "0" bicarb is NOT selected.

Yes See CO- 8.0.0 (page 51).

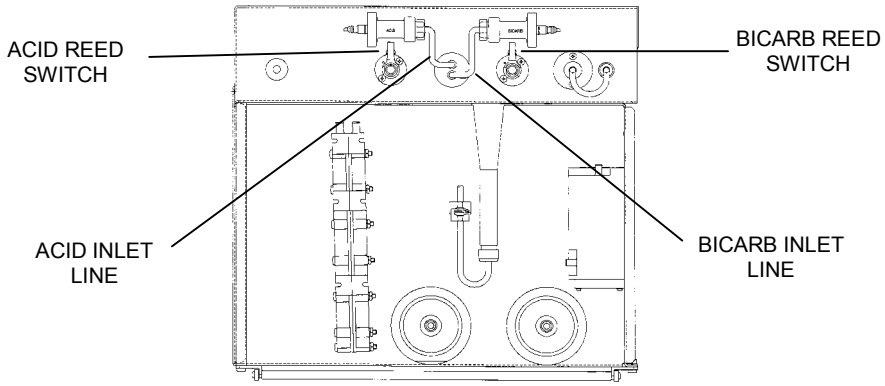
No See CO- 3.0.2

CO- 3.0.2 CHECK CONCENTRATE INLET

THIS IS AN IMPORTANT STEP! Looking through the acid and bicarb inlet lines (see diagram below) is AIR FREE concentrate being pulled steadily, in one direction only (be certain)?

Yes See CO- 5.0.0 (page 49).

No See CO- 3.0.3



CO- 3.0.3 CHECK CONCENTRATE CONNECTOR

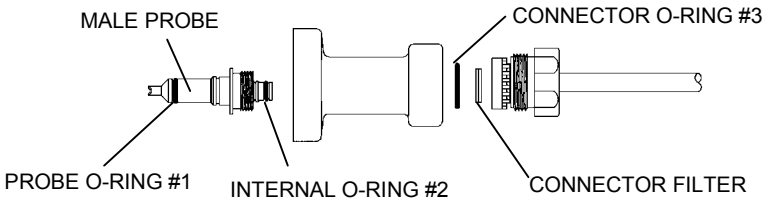
a) Check the concentrate connector filter and o-ring #3 (see diagram below).

b) Place the machine into RINSE mode. Is either concentrate connector leaking?

Yes See CO- 3.0.4

No Allow the machine to run in RINSE for a few minutes (to remove a possible air lock) and return to DIALYZE mode. If the pump still does not draw see CO- 3.0.4

CONCENTRATE CONNECTOR



CO- 3.0.4 CHECK CONNECTOR 0-RINGS

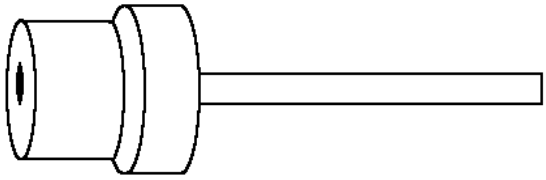
a) Check male probe o-rings #1 and #2 (see diagram, previous page).

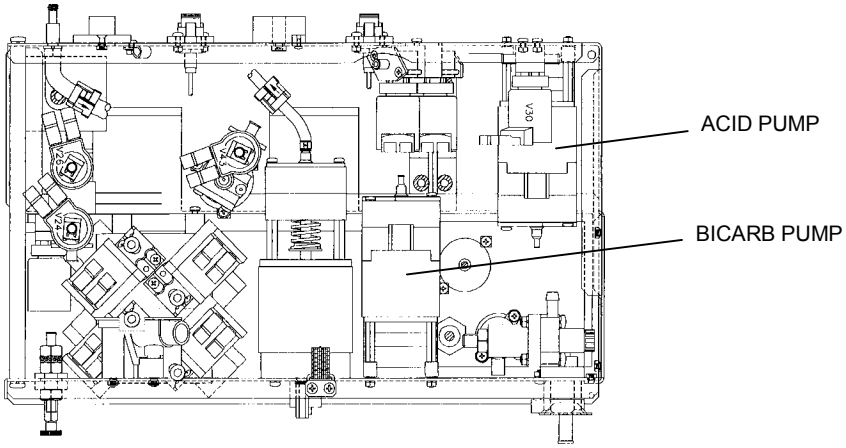
b) If the pump still does not draw, place the entire concentrate connector into water. Does the pump draw now?

Yes The wand is bad (see diagram below).

No Check the concentrate pump for broken springs, bad seals, bad o-rings, bad diaphragm (see diagram below).

WAND





HYDRAULICS, TOP VIEW

CO- 4.0.0 CHECK FOR AIR AT CONDUCTIVITY CELL

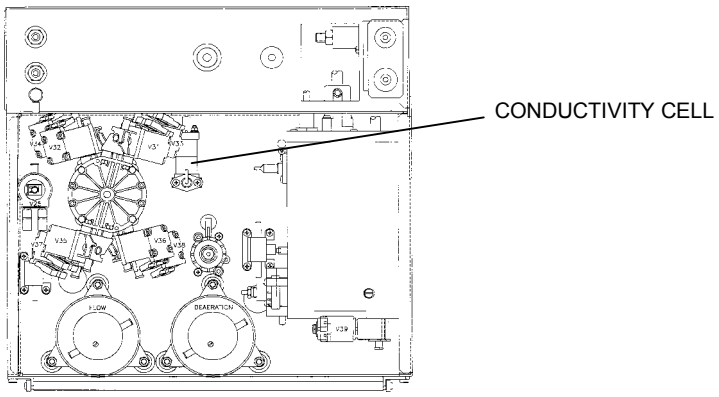
Check the clear tubing at both sides of the conductivity cell (see diagram, next page). Is there excessive air flowing through it?

Yes a) Plug the bicarb connector back into it's port and wait for a few minutes. Check for air again at the cell. If air is not seen a problem is indicated in the bicarb injection system. Check first the bicarbonate connector for bad o-rings.

b) Calibrate DEAERATION PRESSURE by first decreasing the DAC value until pressure is below -18 inHg and then increasing it SLOWLY to -24 inHg.

c) Perform NEGATIVE PRESSURE TESTS (page 62) and INDUCED POSITIVE PRESSURE TESTS (page 65). Look for fluid leaks especially at balancing chamber valves 31 and 33.

No See CO- 4.0.1



HYDRAULICS, REAR VIEW

CO- 4.0.1 CHECK DEBUG CELL VALUES

Assure that the machine has run for 10 minutes with fresh concentrate connected and call up debug screen 23 (frequency values in Hertz). Is FPRE between 1392 and 3072 Hertz or is it 'bouncing' to greater than 8000 Hertz?

Between See CO- 6.0.0

Bouncing Two possibilities; 1) Bad sensor board; 2) Bad actuator board.

CO- 5.0.0 CHECK DEBUG CELL VALUES

Assure that the machine has run for 10 minutes with fresh concentrate connected and call up debug screen 23 (frequency values in Hertz). Is FPRE 1392 and 3072 Hertz?

Yes See CO- 6.0.0

No See CO- 5.0.1

CO- 5.0.1 PERFORM PRESSURE TEST

a) Select a flow rate of 500 ml/min, clear blood alarms, and turn the blood pump rate knob clockwise.

b) Select a UF RATE of 1000 ml/hr and turn UF on (green UF on/off LED MUST be on solid and the UF RATE numeric display must NOT blink).

c) Allow TMP increase to about 260 and then turn UF off. Allow 30 seconds for stabilization.

d) After stabilization does TMP remain stable (within +/- 60 mmHg) for three minutes?

Yes Check BALANCING CHAMBER VOLUME and calibrate *ACID and *BICARB PUMP VOLUMES and CONDUCTIVITY CELL per CALIBRATION PROCEDURES.

No See PRESSURE HOLDING TESTS FAILING (page 60).

* While the pumps are drawing concentrate from the burette determine if each is taking CONSTANT volumes per stroke (in one direction ONLY). If not check the pump's springs, seals, and diaphragm.

CO- 6.0.0 CHECK CONDUCTIVITY CELL

a) Turn flow off and note the FPRE value.

b) Unplug the float from the distribution board (x5, FLOAT-SW) and plug it into the conductivity cell's position (x7, COND). CAUTION Be sure to plug in correctly!

c) From debug screen 23 does the FPRE value go very high?

Yes — Two possibilities: 1) Concentrate is bad or not being pulled by the concentrate pumps; 2) Bad conductivity cell (see diagram, previous page).

No — Remains at previous value. Two possibilities: 1) *Bad sensor board cable; 2) Bad distribution board connection (check carefully for corrosion).

* The sensor cable can be checked for continuity. Note that you are checking the COND CELL connection and see CHECKING THE SENSOR BOARD CABLE (page 74).

CO- 7.0.0 CHECK DEBUG CONDUCTIVITY VALUE

Go to RINSE and call up debug screen 23. After 5 minutes does FPRE= 4000 or less?

Yes — See CO- 7.0.1

No — See CO- 7.0.3

CO- 7.0.1 PERFORM PRESSURE TEST

a) Place the machine into DIALYZE MODE. Select a flow rate of 500 ml/min, clear blood alarms and turn the blood pump rate knob clockwise.

b) Select a UF RATE of 1000 ml/hr and turn UF on (green UF on/off LED MUST be on solid and the UF RATE numeric display must NOT blink).

c) Allow TMP increase to about 260 and then turn UF off. Allow 30 seconds for stabilization.

d) After stabilization does TMP remain stable (within +/- 60 mmHg) for three minutes?

Yes — See CO- 7.0.2

No — See PRESSURE HOLDING TESTS FAILING (page 60).

CO- 7.0.2 CHECK FOR INTERMITTENT FLOW ERROR

Call up debug screen 5 and watch FLWERR very carefully for 10 minutes. Does FLWERR ever go to "1" during this time interval?

Yes — An intermittent flow error is indicated. See F- 9.0.0 (page 10).

No — Check BALANCING CHAMBER VOLUME and calibrate *ACID and *BICARB PUMP VOLUMES and CONDUCTIVITY CELL per CALIBRATION PROCEDURES.

* While the pumps are drawing concentrate from the burette determine if each is taking CONSTANT volumes per stroke (in one direction ONLY). If not check the pump's springs, seals, and diaphragm).

CO- 7.0.3 CHECK FOR 'SHORTED' CONDUCTIVITY CELL

a) Unplug the conductivity cell from the distribution board (position x7, COND) . Check, inside the distribution board, for bent or corroded male pins.

b) Plug the 34°C Fresenius test (temperature) dummy connector into the cell's position (x7, COND). CAUTION! Plug in correctly. From debug screen 23, FPRE =3000 or less?

Yes Replace the conductivity cell (see diagram, page 49).

No See CO- 7.0.4

CO- 7.0.4 CHECK SENSOR BOARD CABLE

a) Turn the power off and unplug both ends of the 34-pin sensor board cable. The sensor board is the smallest board in the card cage (far right). The cable plugs into the top edge and runs into the distribution board.

b) Check for bent or corroded male pins at the sensor and distribution board connectors.

c) Leave the cable unplugged for now and turn the power on. From the SELECT PROGRAM screen push the SET button ONCE and then call up debug screen 19. Is ACON= 3000 or less?

Yes The sensor board cable is bad.

No Two possibilities: 1) Bad sensor board; 2) Bad distribution board

CO- 8.0.0 CHECK BICARB DEBUG SIGNAL

The machine 'thinks' that the blue bicarb connector is plugged into it's port.

Call up debug screen 1. With the bicarb connector out of it's port does BICOUT = "1"

Yes Two possibilities; 1) Bad actuator board; 2) Bad functional board.

No See CO- 8.0.1

CO- 8.0.1 CHECK THE BICARB REED SWITCH

Unplug the bicarb reed switch from distribution board position x12, BIC-SW. Is BICOUT "1" now?

Yes Replace the bicarb reed switch (see diagram, page 47).

No a) Check inside the distribution board for bent or corroded male pins.

b) Unplug the sensor cable from both ends and check the female and male connectors for corrosion.

c) Plug all cables back in and place the machine into dialyze mode. If the problem is still present there are two possibilities; 1) Bad actuator board; 2) Bad functional board.

SECTION 6 - CONCENTRATE PUMP 'END OF STROKE' (EOS) ERRORS

EOS- 1.0.0 DETERMINE THE EOS

Call up debug screen 5:

ACEERR = "1", the ACID pump 'side' is issuing an EOS error. See EOS- 2.0.0

BICERR = "1", the BICARB pump 'side' is issuing an EOS error. See EOS- 3.0.0

EOS- 2.0.0 CHECK ACID PUMP

This procedure uses the bicarb pump (known good) to check the acid pump.

a) Switch the concentrate pump connectors at the distribution board (i.e. Turn the machine OFF then plug the bicarb pump into acid pump's position and visa-versa, see diagram below).

b) Call up debug screen 0 and wait 30 seconds. Are ACID and AACI within 5 units of each other?

Yes Replace the acid pump (or see 2008H ACID & BICARBONATE REPAIR PROCEDURE).

No See EOS- 4.0.0

EOS- 3.0.0 CHECK BICARB PUMP

This procedure uses the acid pump (known good) to check the bicarb pump.

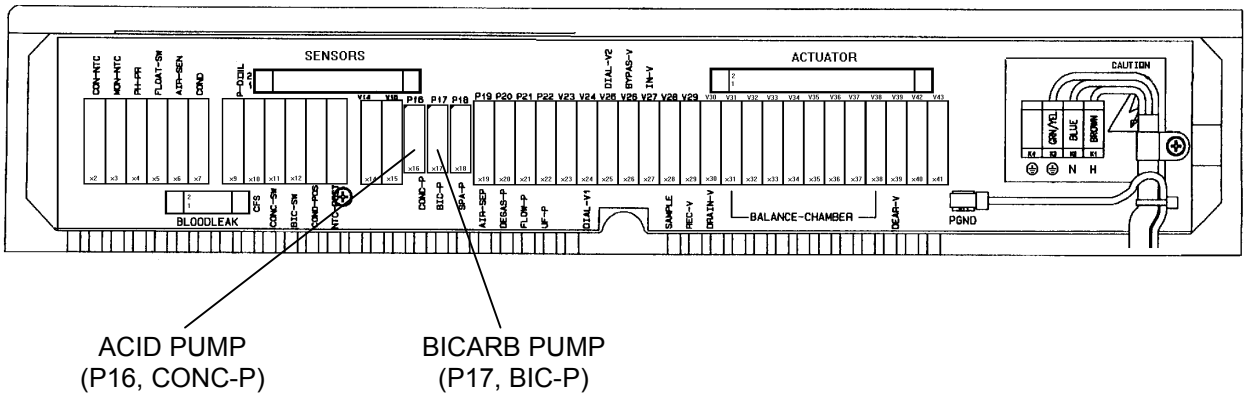
a) Switch the concentrate pump connectors at the distribution board (i.e. Turn the machine OFF then plug the acid pump into bicarb pump's position and visa-versa, see diagram below).

b) Call up debug screen 0 and wait 30 seconds. Are BIC and ABIC within 5 units of each other?

Yes Replace the bicarb pump (or see 2008H ACID & BICARBONATE REPAIR PROCEDURE).

No See EOS- 4.0.0

DISTRIBUTION BOARD



EOS- 4.0.0 CHECK CONCENTRATE PUMP CIRCUIT

Four possibilities: 1) [a]Bad actuator cable; 2) [b]Bad sensor board cable; 3) Bad actuator board; 4) Bad distribution board (check for corrosion).

[a] The actuator cable can be checked. Which 'side' is issuing the error?

ACID	The actuator cable can be checked for continuity. Note that you are checking ACID PUMP connections and see CHECKING THE ACTUATOR BOARD CABLE (page 72).
BICARB	The actuator cable can be checked for continuity. Note that you are checking BICARB PUMP connections and see CHECKING THE ACTUATOR BOARD CABLE (page 72).

[b] The sensor cable can be checked. Which 'side' is issuing the error?

ACID	The sensor cable can be checked for continuity. Note that you are checking the ACID EOS connection and see CHECKING THE SENSOR BOARD CABLE (page 74).
BICARB	The sensor cable can be checked for continuity. Note that you are checking the BICARB EOS connection and see CHECKING THE SENSOR BOARD CABLE (page 74).

SECTION 7 - COND OFFSET REF OR COND OFFSET FAILURES

Perform these procedures ONLY if the machine is issuing "COND OFFSET REF" or "COND OFFSET FAILURE" messages upon power up.

NOTE: If you have changed the SENSOR or FUNCTIONAL board since the last COND CELL CALIBRATION these failures are normal. Perform COND CELL CALIBRATIONS.

CR- 1.0.0 TROUBLESHOOTING OFFSET ERRORS

Attempt to calibrate CONDUCTIVITY CELL per CALIBRATION PROCEDURES. If unsuccessful there are four possibilities: 1) *Bad test board; 2) Bad sensor board; 3) Bad actuator board; 4) Bad functional board.

* NOTE: An alternative to swapping the test board is to remove IC 30 from the test board and run the machine without it. The machine runs ok without IC 30 but will fail tests.

SECTION 8 - FILLING PROGRAM PROBLEMS

FI- 1.0.0 CHECK FLOW ERRORS

Call up debug screen 5. If FLWERR = "1" a flow error is present. Do NOT troubleshoot FILLING PROGRAM PROBLEMS with flow errors present. If FLWERR = "0" proceed to FI- 1.0.1

FI- 1.0.1 CHECK TEMP/COND

Return to the main DIALYSIS screen. Do NOT troubleshoot FILLING PROGRAM PROBLEMS unless COND and TEMP are normal and the BYPASS LED is off. If COND and TEMP are ok proceed to FI- 1.0.2.

FI- 1.0.2 CHECK DEBUG 'FILACT'

a) Assure that the dialysate lines are in the shunt and the shunt door is closed.

b) With TMP less than 100 call up debug screen 7. Is FILACT = "1" or "0"?

"1" See FI- 1.0.4

"0" A FILLING PROGRAM is currently not present. See FI- 1.0.3

FI- 1.0.3 FILLING PROGRAM CHECKS

Generally FILLING PROGRAMS are caused by air leaks. Perform both INDUCED POSITIVE PRESSURE TESTS (page 65) AND NEGATIVE PRESSURE TESTS (page 62) to locate a leak if:

- the message "10 FILL PROGRAMS IN 1 HR" is coming up on the screen
- FILLING PROGRAM is occurring ONLY at high TMP values

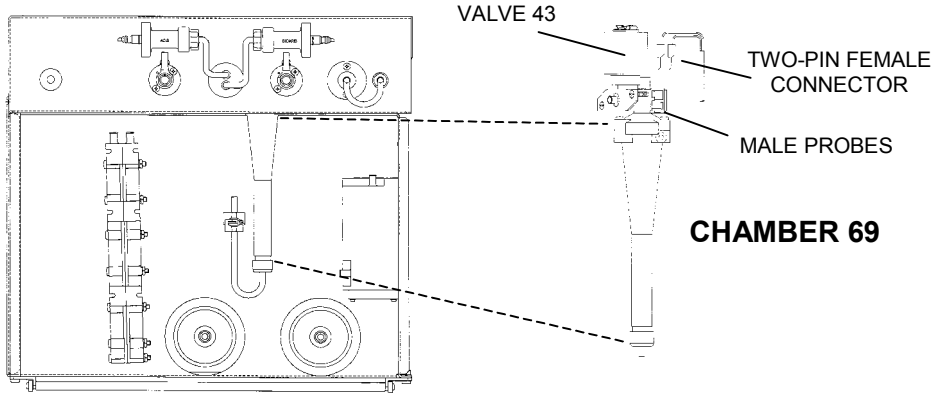
FI- 1.0.4 CHECK AIR SENSOR

a) Assure that the two-pin female connector is plugged onto male probes at chamber 69 (see diagram below). Brown at the top probe, blue at the bottom. If ok proceed.

b) Unplug the female connector and connect both ends together. Wait 30 seconds. Does FILACT = "0"?

Yes See FI- 1.0.5

No See FI- 1.0.6



HYDRAULICS, FRONT VIEW

FI- 1.0.5 CHECK CONNECTOR

Place the female connector back onto the probes (brown at top probe, blue at bottom) and wait 30 seconds. Does FILACT remain "0"?

Yes a) Check the two-pin wiring female connector and harness for bare wires. Replace if bare.

b) Check for a 'tight' connection between the female connector and the male probes.

No FILACT = "1". If conductivity is normal a problem is indicated with the male probes.

FI- 1.0.6 CHECK AIR REMOVAL HARNESS

a) Unplug the air sensor connector from distribution board position x6, AIR-SEN. Check, inside the distribution board, for bent, broken or corroded male pins.

b) Place a jumper wire, between male pins 1 and 5 (top and bottom). CAUTION! Make sure that you put the jumper into the correct distribution board position. Does FILACT = "0"?

Yes The two-pin female connector is bad (open).

No See FI- 1.0.7

FI- 1.0.7 CHECK SENSOR BOARD

a) Place the female connector back onto the probes (brown at top probe, blue at bottom).

b) Plug the air sensor connector back into the distribution board position x6, AIR-SEN.

CAUTION! Be careful to plug in correctly.

c) Turn the power off go to T&C by turning on dipswitch 7 on the functional board.

d) Swap in a sensor board and turn the power back on. Return to DIALYZE MODE.

e) Wait until conductivity comes up and call up debug screen 7. Is FILACT "1" or "0"?

"1" Two possibilities: 1) *Bad sensor board cable; 2) Bad functional board.

0" The previous sensor board is bad.

* The sensor cable can be checked for continuity. Note that you are checking the AIR SENSOR connection and see CHECKING THE SENSOR BOARD CABLE (page 74).

SECTION 9 - TMP PROBLEMS

TM- 1.0.0 CHECK FOR FLOW ERROR

Call up debug screen 5. If FLWERR = "1" a flow error is present. Do NOT troubleshoot TMP PROBLEMS with flow errors present. If FLWERR = "0" proceed to TM- 1.0.1

TM- 1.0.1 CHECK FOR FILLING PROGRAM

Call up debug screen 7. If FILACT = "1" a FILLING PROGRAM is present. Do NOT troubleshoot TMP PROBLEMS until FILLING PROGRAM is clear. If FILACT = "0" proceed to TM- 1.0.2

TM- 1.0.2 CHECK TMP FAULT

Push SET to return to the main screen. Is TMP 'pegged' at either +60 or 520 mmHg?

Yes See TM- 1.0.3

No Perform pressure holding tests (negative flow on/positive flow off). If both pass a TMP problem is not indicated.

TM- 1.0.3 ADJUST TMP

a) Push RESET. The message "ADJUST TMP?" comes up on the screen.

b) Push and hold RESET until "ADJUST TMP" is up. Does TMP move from it's previous value?

Yes See TM- 1.0.4

No See TM- 2.0.0

TM- 1.0.4 CHECK FOR TMP PEGGING

Does TMP return quickly (within 30 seconds) to it's previous 'pegged' value?

Yes See TM- 1.0.5

No Perform pressure holding tests (negative flow on/positive flow off). If both pass a TMP problem is not indicated.

TM- 1.0.5 PERFORM PRESSURE TEST

This procedure will determine if a problem is located in the balancing chambers.

a) Adjust TMP from it's 'pegged' value, clear blood alarms, and turn the blood pump rate knob clockwise.

b) Select a UF RATE of 1000 ml/hr and turn UF on (green UF on/off LED MUST be on solid and the UF RATE numeric display must not blink).

c) Allow TMP increase to about 260 and then turn UF off.

d) Turn flow off and allow 30 seconds for stabilization. Does TMP remain stable (within +/- 40 mmHg) for three minutes?

Yes See TM- 1.0.6

No Four possibilities:

1) Hydraulic leak. Perform both INDUCED POSITIVE PRESSURE TESTS (page 65) AND NEGATIVE PRESSURE TESTS (page 62) to locate a possible leak;

2) Leaking valve. Perform VALVE LEAK TEST from SERVICE/DIAGNOSTICS;

3) Dialysate pressure out of calibration (see CALIBRATION PROCEDURES, section 2.3);

4) Bad dialysate pressure transducer #9 (see diagram A, page 5).

TM- 1.0.6 PERFORM VALVE LEAK TESTS

A problem is indicated in the balancing chambers.

a) Place the machine into SERVICE/DIAGNOSTICS.

b) Select #11 VALVE LEAK TEST and wait until the "READY" message appears.

c) Push SET twice to start the tests. Is a balancing chamber valve (valves 31 through 38) leak indicated?

Yes Unplug the leaking valve from the distribution board (for example, valve 36 plugs into position V36) and measure for voltage, inside the distribution board, between male pins 1 and 5 (top and bottom). If one vdc or greater replace the actuator board otherwise replace the indicated leaking valve.

No See MANUAL BALANCING CHAMBER VALVE LEAK TESTS (page 76) if a leak is not found perform TESTING FOR A LEAKING BALANCING CHAMBER DIAPHRAGM (page 79).

TM- 2.0.0 CHECK SENSOR BOARD DEBUG VALUE (PDIA)

a) Turn the flow off, remove the dialysate lines from the shunt and drop them into a bucket of water on the floor.

b) Close the shunt door (important).

c) Call up debug screen 9. Is PDIA between 4.0 and 7.0 vdc?

Yes See TM- 2.0.3

No See TM- 2.0.1

TM- 2.0.1 CHECK ACTUATOR BOARD DEBUG VALUE (ADIA)

Call up debug screen 11. Is ADIA between 3.0 and 6.0 vdc?

Yes Replace the sensor board.

No See TM- 2.0.2

TM- 2.0.2 CHECK DIALYSATE PRESSURE TRANSDUCER

This procedure tests the dialysate pressure transducer using the known good CFS transducer.

a) Unplug the CFS and dialysate pressure transducers from their respective distribution board positions (x10, CFS)(x9, P-DIAL).

b) Plug the CFS connector into position x9, P-DIAL. CAUTION! Be sure to plug in correctly.

c) From debug screen 11. Does ADIA read between 3.0 and 6.0 vdc?

Yes Return the transducers to their correct distribution board positions (important). Calibrate DIALYSATE PRESSURE per CALIBRATION PROCEDURES, section 2.3. If not successful replace the dialysate pressure transducer #9 (see diagram A, page 5) and calibrate.

No See TM- 2.0.4

TM- 2.0.3 CHECK TMP

Push SET to return to the main screen. Is TMP between 0 and 100 mmHg?

Yes Return the lines to the shunt door and perform pressure holding tests (negative flow on/positive flow off). If both pass a problem is not indicated.

No Calibrate DIALYSATE PRESSURE per CALIBRATION PROCEDURES, section 2.3. If not successful replace the dialysate pressure transducer #9 (see diagram A, page 5) and calibrate.

TM- 2.0.4 CHECK TEST BOARD

a) Leave the CFS transducer plugged into position x9, P-DIAL for now.

b) Turn the power off and swap in a new test board. NOTE An alternative is to remove IC 4 from the test board. The machine runs fine without IC 4 but will fail tests.

c) Turn the power on and enter DIALYZE mode. From debug screen 11, is ADIA between 3.0 and 7.0 vdc?

Yes The previous test board (or IC 4) is bad. CAUTION! Make sure to plug the transducers back into their correct distribution board positions.

No See TM- 2.0.5

TM- 2.0.5 CHECK DIALYSATE PRESSURE CIRCUIT

a) IMPORTANT return the transducers to their correct distribution board positions.

b) Four possibilities: 1) *Bad sensor board cable; 2) Bad sensor board; 3) Bad actuator board; 4) Bad functional board.

* The sensor cable can be checked for continuity. Note that you are checking DIALYSATE TRANSDUCER connections and see CHECKING THE SENSOR BOARD CABLE (page 74).

SECTION 10 - PRESSURE HOLDING TESTS FAILING

NOTE: These procedures assume that DIALYSATE PRESSURE has been calibrated accurately.

PH- 1.0.0 CHECK LOADING PRESSURE

Insert the loading pressure gauge tightly into the ACID/ACETATE port. This pressure should be between 18 and 20 psi. Calibrate as necessary and run PRESSURE HOLDING TESTS again. If loading pressure is ok proceed to PH- 1.0.1

PH- 1.0.1 CHECK FOR LEAKS

Look for obvious fluid leaks inside the hydraulic compartment and at the external dialysate lines (especially the hansen connectors). If a leak is not seen proceed to PH- 1.0.2

PH- 1.0.2 CHECK DEAERATION

a) Turn the flow off and wait 60 seconds or until you hear the deaeration pump turn off.

b) Tee a negative pressure gauge between the clear (INPUT) line and the deaeration pump's input nozzle (see diagram, page 63).

c) Turn flow on at a 500 flow rate. Deaeration pressure -24 inHg to -25 inHg?

Yes See PH- 1.0.3

No See DEAERATION PROBLEMS (page 66).

PH- 1.0.3 PERFORM INDUCED POSITIVE PRESSURE TESTS

Read this entire step before proceeding. Run INDUCED POSITIVE PRESSURE TESTS (page 65) to locate a possible fluid leak. If a leak not seen proceed to PH- 1.0.4

PH- 1.0.4 PERFORM TMP PUMP UP

a) Clear ALL blood alarm messages and turn the blood pump rate above 90 mL/min.

b) Select a UF RATE of 1000 ml/hr and turn UF on (green UF on/off LED MUST be on solid and the UF RATE numeric display MUST NOT blink). Does TMP increase to 280 or greater?

Yes Run NEGATIVE PRESSURE TESTS (page 62) to locate a possible air leak. If a leak is not found see PH- 1.0.6

No See PH- 1.0.5

PH- 1.0.5 CHECK UF PUMP

CLEAR all blood alarms. With UF ON determine if the UF pump is stroking by checking compressions of the large external spring (see diagram, page 62). Is the pump stroking?

Yes See PH- 1.0.6

No See UF PUMP PROBLEMS (page 67).

PH- 1.0.6 VALVE LEAK TESTS

a) Place the machine into SERVICE/DIAGNOSTICS. Select #11 VALVE LEAK TEST and wait until the "READY" message appears.

b) Push SET TWICE to start the tests. Valve leak indicated?

Yes Run VALVE LEAK TEST AGAIN on the bad valve to confirm. If it fails again see PH- 1.0.7

No Return to DIALYZE MODE and run PRESSURE HOLDING TESTS (negative flow on/positive flow off). If still failing see PH- 1.0.9

PH- 1.0.7 DETERMINE THE LEAK

"VALVE 44 FAILURE": Perform INDUCED POSITIVE PRESSURE TESTS (page 65) and check for a fluid leak especially in the vicinity of air removal chamber #69 (see diagram, page 65).

ONE VALVE LEAKING: See PH- 1.0.8

VALVES 29/30 LEAKING: May also indicate a leaking heat exchanger. TIGHTLY clamp the tubing at the input nozzles of valve 30 AND 29 (see diagram, page 62) and run VALVE LEAK TESTS again. If the test fails the heat exchanger is leaking (see diagram, page 65). If the test passes remove the clamp from valve 30 **only** and run VALVE LEAK TESTS once again. If the test fails valve 30 may be leaking (see PH- 1.0.8). If the test passes valve 29 may be leaking (see PH- 1.0.8).

MORE THAN ONE VALVE LEAKING: a) Check UF pump check valves #63 and #64 (see diagram, page 67); b) Perform both INDUCED POSITIVE PRESSURE TESTS (page 65) **AND** NEGATIVE PRESSURE TESTS (page 62) to locate a possible fluid leak; c) Calibrate DIALYSATE PRESSURE per CALIBRATION PROCEDURES, section 2.3.

PH- 1.0.8 CHECK FOR SHORTED ACTUATOR BOARD VALVE DRIVER

Leave the machine in DIAGNOSTICS with the failure message on the screen. Unplug the indicated leaking valve from the distribution board (for example, valve 33 plugs into position V33) and measure dc voltage between **male** pins 1 and 5 (top and bottom) inside the distribution board. One vdc (or greater) replace the actuator board otherwise replace the leaking valve.

PH- 1.0.9 MANUAL PRESSURE TEST

a) Select a flow rate of 500 ml/min, clear all blood alarms and turn the blood pump rate knob clockwise.

b) Select a UF RATE of 1000 ml/hr and turn UF on (green UF on/off LED MUST be on solid and the UF RATE numeric display MUST NOT blink).

c) Allow TMP increase to about 260 and then turn UF off. Turn FLOW OFF and allow 30 seconds for stabilization. Does TMP remains stable (within +/- 40 mmHg) for three minutes?

Yes A leak in the balancing chamber is indicated. Perform MANUAL BALANCING CHAMBER VALVE LEAK TESTS (page 76). If a leaking valve is not found perform TESTING FOR A LEAKING BALANCING CHAMBER DIAPHRAGM (page 79).

No Perform both INDUCED POSITIVE PRESSURE TESTS (page 65) AND NEGATIVE PRESSURE TESTS (page 62) to locate a possible fluid leak.

SECTION 11 - NEGATIVE PRESSURE TESTS

These tests use negative pressure to locate a hydraulic leak.

I. It is assumed that deaeration pressure has been previously checked to -24 inHg to -25 inHg.

II. Using a flashlight is helpful. All checks are done by looking through clear hydraulic tubing.

A- 1.0.0 CHECK FOR AIR LEAK

a) Assure that the dialysate lines are in the shunt and the door is closed.

b) Clear ALL dialysate and blood alarms and turn the blood pump rate knob fully clockwise.

c) Select a UF RATE of about 1000 ml/hr and turn the UF on (the green UF on/off LED MUST be on solid and the UF RATE numeric display MUST NOT blink).

d) Allow the TMP to increase to about 260 and turn the UF off.

NOTE: A TMP of 300 (or greater) should be maintained to run these tests. Air bubbles are larger and much easier to see at higher TMP.

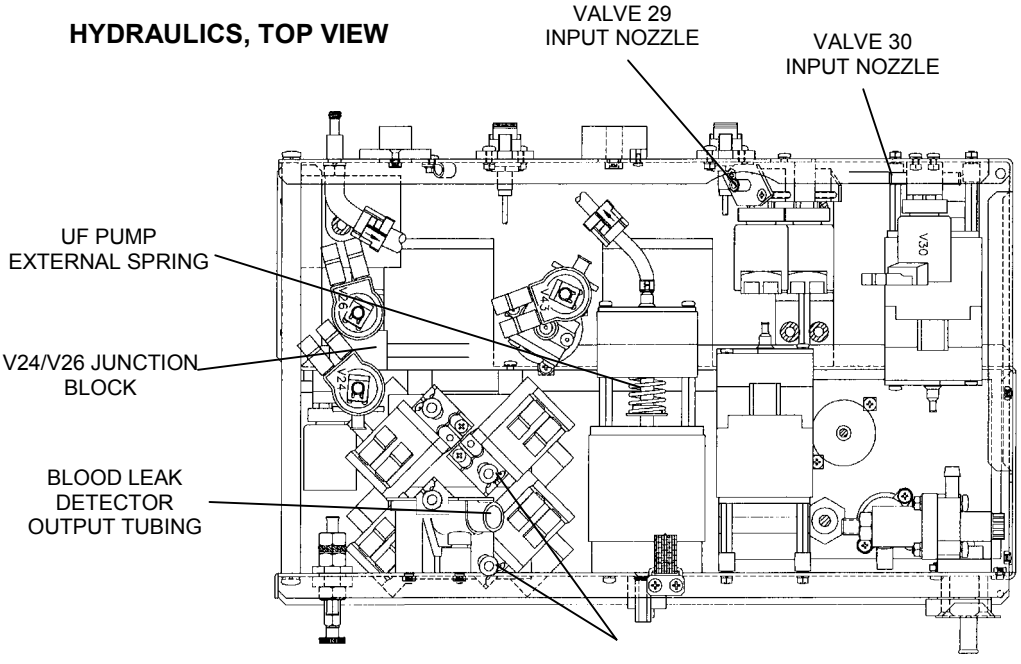
e) Look through the clear tubing at the OUTPUT of the blood leak detector tubing (see diagram below), are *large air bubbles seen?

Yes See A- 1.0.1

No An air leak is not obvious using this test. Return to previous procedures and proceed accordingly

* Smaller air bubbles may be 'normal'. Check another machine (that is passing pressure holding tests) to determine what 'normal' looks like.

HYDRAULICS, TOP VIEW



A- 1.0.1 LOCATING THE LEAK

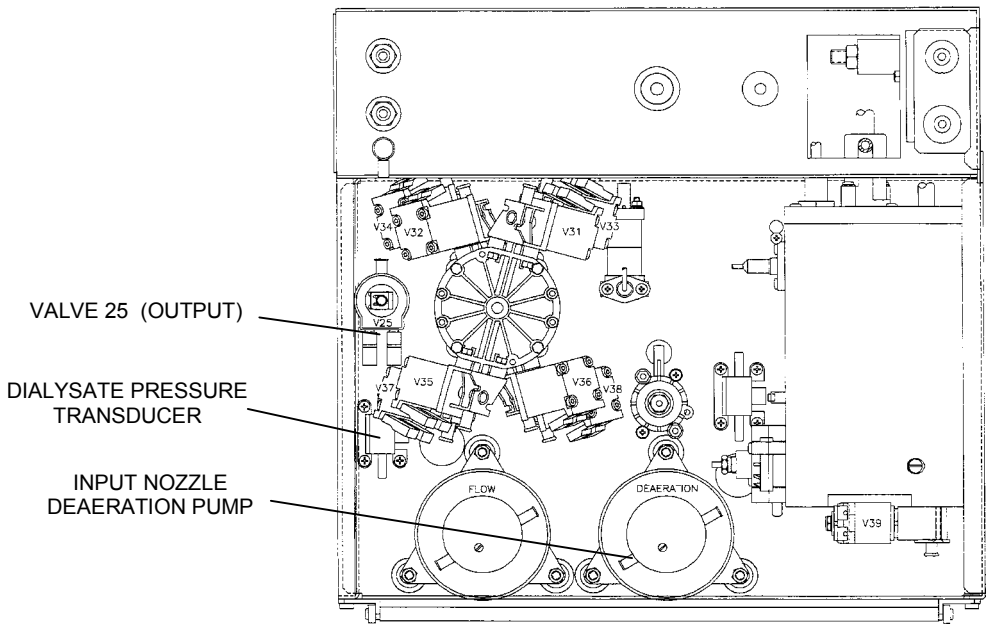
Check for air bubbles at the following locations in the following order:

NOTE: TMP must be maintained at about 300 for these tests.

1. OUTPUT tubing at valve 25 (see diagram below). If air is not seen check the tubing connections at the blood leak detector and dialysate pressure transducer.
2. INPUT tubing at the external dialysate line filter (73) (see diagram A, page 5). If air is not seen check the o-ring inside the filter housing.
3. INPUT tubing at the venous (blue) hansen connector. If air is not seen replace the hansen connector o-rings
4. INPUT tubing at the external flow indicator (75) (see diagram A, page 5). If air is not seen check the o-rings inside the indicator.
5. INPUT tubing at the valve 24/26 junction block (see diagram, previous page). If air is not seen check the block for bad o-rings or cracks.
6. OUTPUT tubing from balancing chamber valves 31 and 33 (see diagram, previous page). If air is not seen check the tubing connections at the conductivity cell #7.
7. Is air coming from ONE or BOTH valves 31 and 33?

   One Check the connection (and o-ring) between the leaking valve and the balancing chamber.

   Both See A- 1.0.2



HYDRAULICS, REAR VIEW

A- 1.0.2 CHECK BICARB INLET SYSTEM

a) Check the clear bicarb inlet line for air. If air is seen check for a loose connection or bad o-rings at the bicarb connector.

b) Plug the bicarbonate connector back into it's port. After a few minutes check at balancing chamber valves 31 and 33. Is air still present?

Yes
a) Calibrate DEAERATION PRESSURE by first decreasing the DAC value until pressure is below -18 inHg and then increasing it SLOWLY until -24 inHg is obtained.

b) Perform both the INDUCED POSITIVE PRESSURE TESTS (page 65) AND NEGATIVE PRESSURE TESTS (page 62) to locate a possible leak (especially at balancing chamber valves 31 and 33).

No
Check the bicarb pump (o-rings), the injection site, and the mixing chamber #82 for an air leak.

SECTION 12 - INDUCED POSITIVE PRESSURE TESTS

These tests use positive pressure to locate a hydraulic leak.

NOTE: These tests must be done from DIALYZE MODE.

a) At the top of the air removal chamber #69 is valve 43 and two male probes (see diagram below).

b) Unplug the two-pin female connector from each probe and place them such that they cannot come into contact with each other. A FILLING PROGRAM should be now be present (debug screen 7, FILACT = "1").

c) Clamp the clear tubing from valve 43's output nozzle. During FILLING PROGRAM the only path to drain is through valve 43. By clamping valve 43 this path is removed and the secondary hydraulic side is pressurized to loading pressure (+19 ± 1 psi).

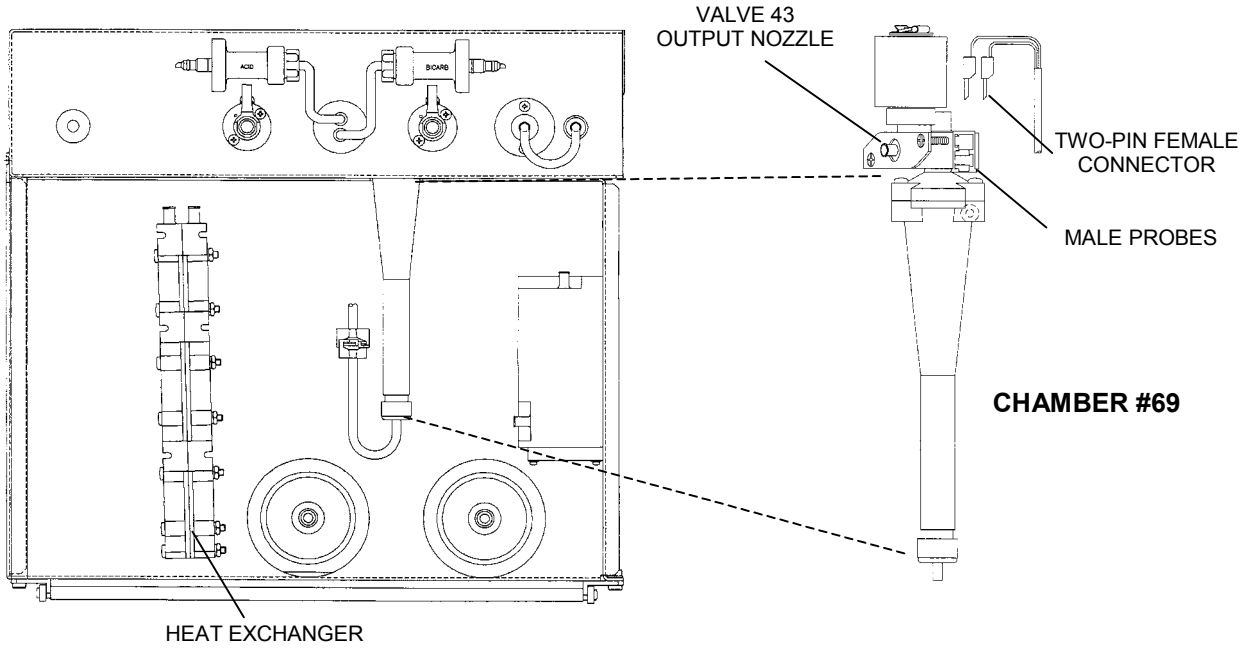
d) A flow error should become present (debug screen 5, FLWERR = 1). Push the SET key. TMP should = +60.

e) Remove the UF sample tube from the front of the machine and check for fluid leaks indicative of a bad UF pump output spring AND check valve #63.

f) Wait for SEVERAL minutes and then CAREFULLY search for fluid leaks. Look ESPECIALLY in the area of air removal chamber #69, flow pump tubing (input and output) and the flow pump regulator #78.

g) If a leak is not seen return the female connectors to the air removal chamber probes, unclamp valve 43, and return to previous procedures.

HYDRAULICS, FRONT VIEW



SECTION 13 - DEAERATION PROBLEMS

D- 1.0.0 CHECK DEAERATION SYSTEM

a) Turn flow off and call up debug screen 17. Wait until DEAP = 255 and check the deaeration pump's motor shaft (diagram on page 6). If still rotating replace the actuator board (bad driver), otherwise proceed to part b.

b) Attempt DEAERATION CALIBRATION per procedure. If unsuccessful proceed to part c.

c) Clamp the solid tubing between valve 39 and the hydroblock (see diagram below) and attempt DEAERATION CALIBRATION again. Calibrate properly?

Yes See D- 1.0.2

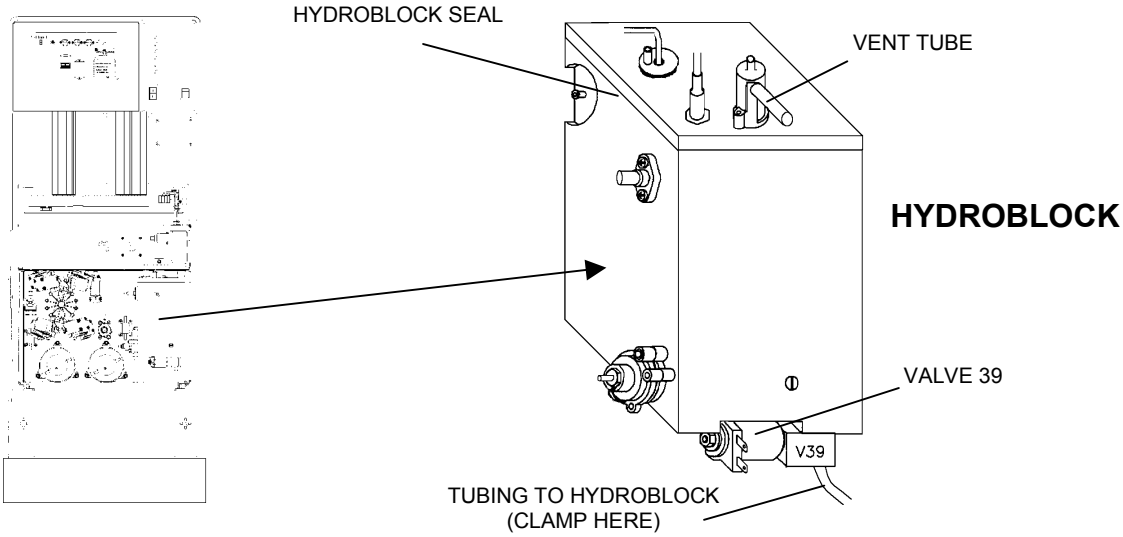
No Replace the deaeration pump head and attempt DEAERATION CALIBRATION. If not successful see D- 1.0.3 (the previous pump head is probably good).

D- 1.0.2 CHECK ACTUATOR BOARD

Remove the clamp from valve 39. Unplug valve 39 from the distribution board (V39, DEAR-V). Deaeration pressure return to good?

Yes Replace the actuator board.

No Replace valve 39.



D- 1.0.3 CHECK HYDROBLOCK

a) Turn the flow off and unplug the float from the distribution board (x5, FLOAT-SW). Place a jumper wire, inside the distribution board, between male pins 1 and 3 (top and middle). Water should eventually overflow from the vent tube.

b) Clamp the vent tube to pressurize the hydroblock to inlet water pressure (19 ± 1 psi) and look for a fluid leak at the top seal of the hydroblock (see HYDROBLOCK diagram above). Is a leak seen?

Yes Try tightening the screws that mounts the hydroblock cover to the hydroblock. If the leak continues replace the hydrobock seal (part # 565642).

No Two possibilities: 1) Bad actuator board; 2) Bad deaeration pump motor

SECTION 14 - UF PUMP PROBLEMS

UF- 1.0.0 CHECK DEBUG UFPULS

With UF OFF (important) call up debug screen 1. Is UFPULS = "1"?

Yes See UF- 2.0.0

No See UF- 1.0.1

UF- 1.0.1 CHECK UF PUMP

a) Place the dialysate lines into a bucket of (conductive) water.

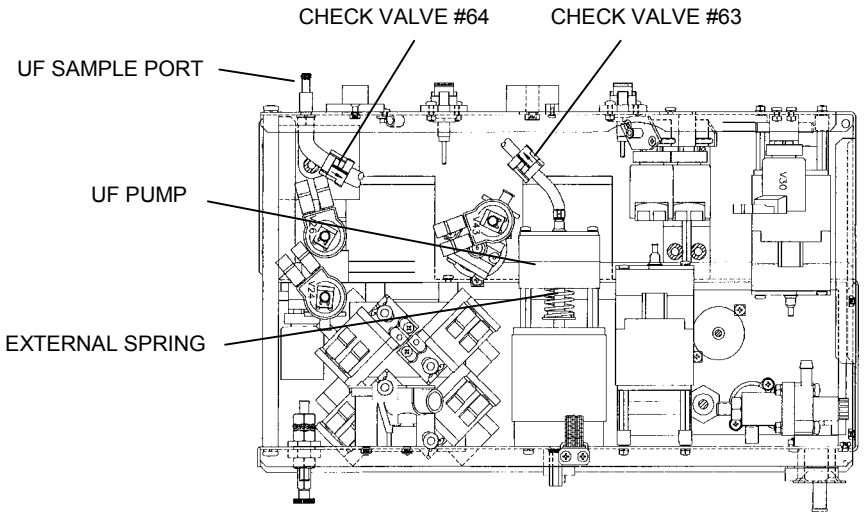
b) Clear all blood alarms and turn the blood pump rate knob fully clockwise.

c) Select a UF RATE of 1000 ml/hr and turn UF on (IMPORTANT the green UF on/off LED MUST remain on solid and the UF RATE numeric display MUST NOT blink).

d) Determine if the UF pump is stroking by watching for compressions of the large external spring (see diagram below). Is the UF pump stroking?

Yes See UF- 1.0.3

No Turn UF off and see UF- 1.0.2



HYDRAULICS, TOP VIEW

UF- 1.0.2 CHECK ACTUATOR BOARD

a) Remove the cover from the UF pump's distribution board connector (P22, UF-P) and then plug the connector back in. CAUTION Be careful to plug in correctly!

b) Clamp meter leads between pins 1 and 5 (top and bottom, where the wires are attached).

c) Clear all alarms and turn UF on (green UF on/off LED MUST be on solid and the UF RATE numeric display MUST NOT blink). UF rate set to 1000 ml/hr.

d) Voltage to the connector should 'pulse' from between 26 and 22 vdc to less than 2 vdc. Is this ok?

Yes Replace the UF pump.

No Replace the actuator board.

UF- 1.0.3 CHECK UF OUTPUT

With UF on, remove the UF output tube from the sample port (see diagram, previous page). Are there 'strong' output strokes from the tube?

Yes See UF- 1.0.4

No a) Make sure check valve #63 is oriented properly (see diagram, previous page).

b) Check the UF pump for broken springs, bad o-rings, or a bad diaphragm.

UF- 1.0.4 CHECK TMP PUMP UP

a) Turn UF off and place the dialysate lines back into the shunt.

b) Clear all blood alarms and turn UF on. Does TMP (main screen) increase to 280 or greater?

Yes Make sure check valve #64 is oriented properly (see diagram, previous page).

No See UF- 1.0.5

UF- 1.0.5 CHECK DIALYSATE PRESSURE

a) Turn UF off and tee a three-way connector into the dialysate lines with one leg going to an external pressure meter.

b) Clear all blood alarms and turn UF on. Does meter pressure increase to greater than -260 mmHg?

Yes Calibrate DIALYSATE PRESSURE per CALIBRATION PROCEDURES, section 2.3.

No Perform both NEGATIVE PRESSURE TESTS (page 62) AND INDUCED POSITIVE PRESSURE TESTS (page 65) to locate a hydraulic leak.

UF- 2.0.0 CHECK UF PUMP SOLENOID RESISTANCE

a) Unplug the UF pump from distribution board position P22, UF-P.

b) Remove the plastic cover and measure resistance between the two soldered wires inside the female connector. Between 8 and 12 ohms?

Yes Two possibilities: 1) *Bad actuator board cable; 2) Bad actuator board.

No Replace the UF pump.

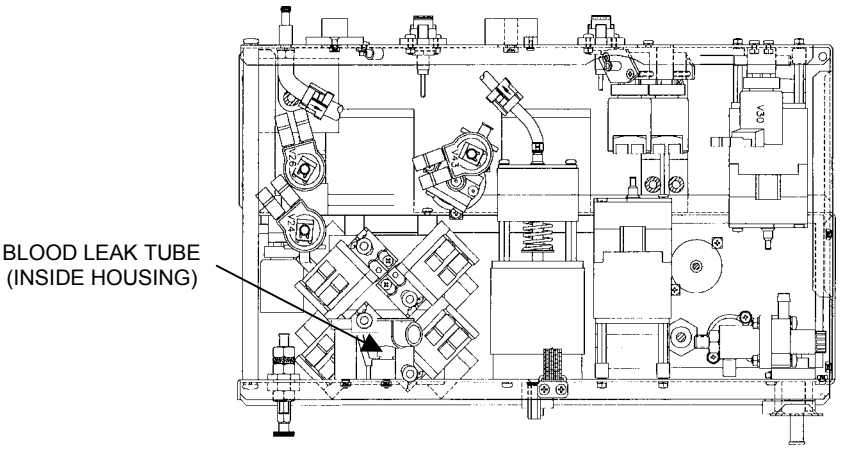
* The actuator cable can be checked for continuity. Note that you are checking UF PUMP connections and see CHECKING THE ACTUATOR BOARD CABLE (page 72).

SECTION 15 - BLOOD LEAK PROBLEMS

NOTE: Do not proceed unless the BYPASS LED is off (i.e. out of bypass).

BL- 1.0.0 CHECK DIMNESS

Call up debug screen 9. If DIMN is greater than 5.5 or less than 4.0 vdc check the blood leak detector's glass tube for calcium (the tube appears 'cloudy') and air bubbles. If calcium is seen run BLEACH/RINSE. If air is seen perform NEGATIVE PRESSURE TESTS and/or INDUCED POSITIVE PRESSURE TESTS to locate the leak.



HYDRAULICS, TOP VIEW

BL- 2.0.0 CHECK LEAK

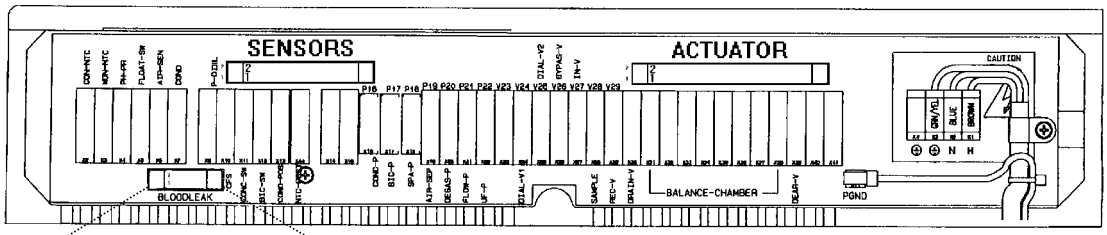
From debug screen 9, if LEAK is greater than 5.2 or less than 4.5 vdc attempt BLOOD LEAK calibrations (DETECTOR and DIMNESS, sections 2.6.1 and 2.6.2, CALIBRATION PROCEDURES).

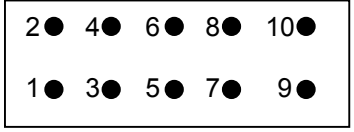
BL- 3.0.0 CHECK BLOOD LEAK SIGNALS

a) Turn the power off and place a ground lead at TEST connector SGND (see CARD CAGE diagram, page 71).

b) Unplug the blood leak detector from the distribution board's x8 connector. Measure dc voltages at the male pins specified in the BLOOD LEAK SIGNALS table (page 70). Follow the instruction given.

DISTRIBUTION BOARD





X8 CONNECTOR

BLOOD LEAK SIGNALS (at x8 connector)

PIN	GOOD (vdc)	BAD
3 (+12V)	11.4 to 12.6, measure at pin 6	Sensor board cable
6 (TEST)	Between 0 and 1, measure at pin 7	[1]Sensor board cable or test board (IC 44)
7 (LEAK)	See **DAC PROCEDURE:** **a)** With DAC set at " 255" voltage = between 9.5 and 10.0 **b)** With DAC set at "0" voltage = between 0 and 0.5, measure at pin 9	[2]Sensor cable or sensor board (IC 6)
9 (DIMN)	See **DAC PROCEDURE:** **a)** With DAC set at " 255" voltage = between 9.5 and 10.0 **b)** With DAC set at "0" voltage = between 0 and 0.5, see BL- 4.0.0	[3]Sensor cable or sensor board (IC 6)

[1] The sensor cable can be checked for continuity. Note that you are checking the BLOOD LEAK **TEST** connection and see CHECKING THE SENSOR BOARD CABLE (page 74)

[2] The sensor cable can be checked for continuity. Note that you are checking the BLOOD LEAK **SENSOR** connection and see CHECKING THE SENSOR BOARD CABLE (page 74)

[3] The sensor cable can be checked for continuity. Note that you are checking the BLOOD LEAK **DIMNESS** connection and see CHECKING THE SENSOR BOARD CABLE (page 74)

DAC PROCEDURE

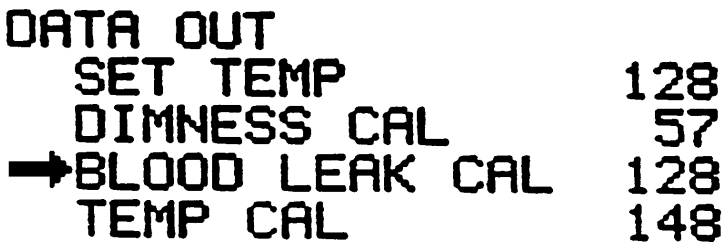
Place the machine into SERVICE mode and enter DIAGNOSTICS/7, OUTPUT TO D TO A. There are two parts to this procedure:

PART I (While measuring voltage at connector x8, pin 7).

a) Select and change the BLOOD LEAK CAL value to "255".

b) Move the pointer in front of BLOOD LEAK CAL (as shown) and **PRESS** the SET button.

WARNING! Not pushing SET results in incorrect voltages.



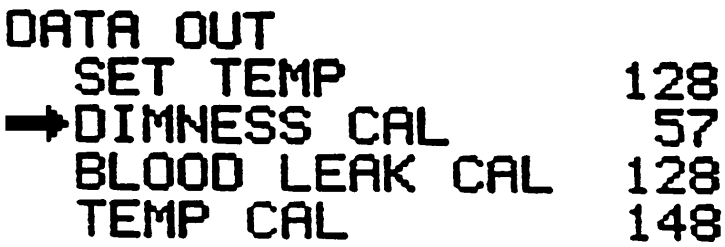
c) Repeat procedure, this time setting BLOOD LEAK CAL to "0". Move the pointer in front and **PRESS** the SET button.

WARNING! Not pushing SET results in incorrect voltages.

PART II (While measuring voltage at connector x8, pin 9).

a) Select and change the DIMNESS CAL value to "255".

b) Move the pointer in front of DIMNESS CAL (as shown) and **PRESS** the SET button. **WARNING!** Not pushing SET results in incorrect voltages.



c) Repeat procedure, this time setting DIMNESS CAL to "0". Move the pointer in front and **PRESS** the SET button. **WARNING!** Not pushing SET results in incorrect voltages.

BL- 4.0.0 CHECK SENSOR BOARD BLOOD LEAK OUTPUT

a) Turn the power off and take the machine out of SERVICE mode.

b) Plug the blood leak detector back into the distribution board.

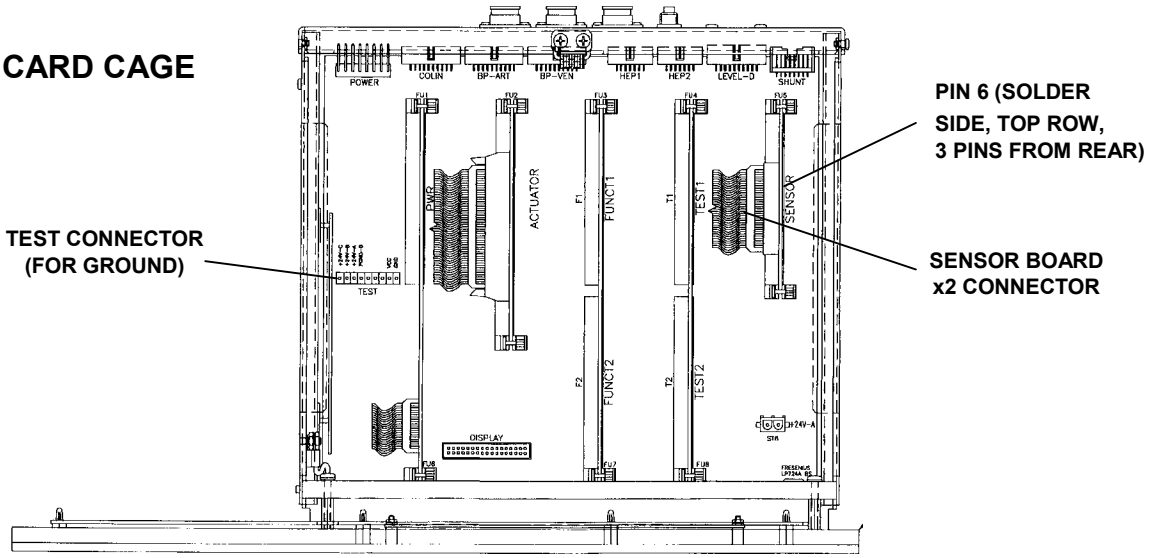
c) Turn the power back on and return to DIALYZE mode.

d) Measure voltage, from the back (solder) side of the sensor board's, x2 connector at pin 6 (see diagram below). Between 4.5 and 5.2 vdc?

Yes Currently a problem is NOT indicated. Possible intermittent blood leak sensor.

No Two possibilities: 1) [4]Sensor board cable; 2) Bad blood leak detector.

[4] The sensor cable can be checked for continuity. Note that you are checking the BLOOD LEAK **OUTPUT** connection and see CHECKING THE SENSOR BOARD CABLE (page 74)



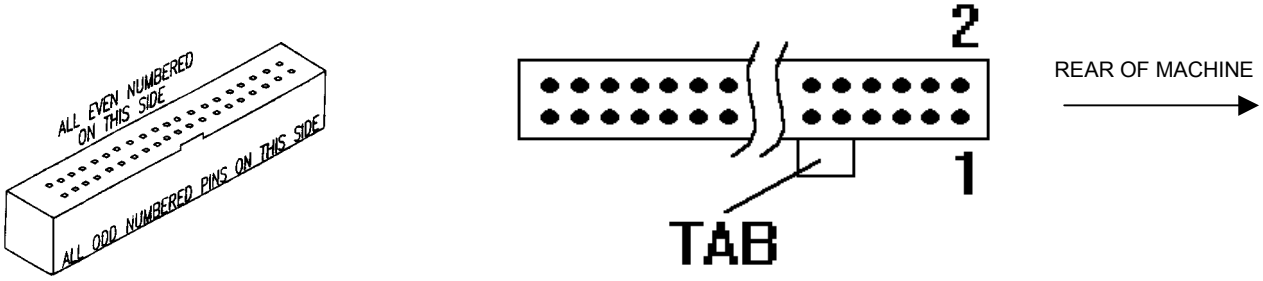
SECTION 16 - CHECKING THE ACTUATOR BOARD CABLE

a) Turn the POWER OFF and unplug the actuator board cable from the distribution board (ACTUATOR CONNECTOR).

b) Using a flashlight, check inside the male connector for bent or broken pins. Check also for signs of corrosion.

c) Check the female cable end for signs of corrosion. The cable ends are arranged in two rows, even in one row, odd in the other. The TAB identifies the 'odd' row.

FEMALE CONNECTOR

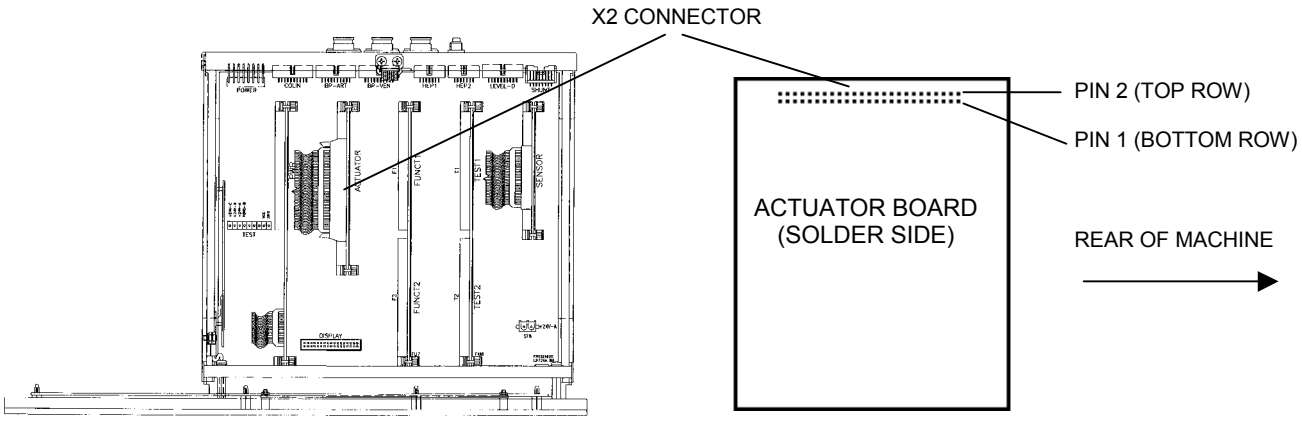


d) Inside the card cage the cable terminates at connector X2 (actuator board). The solder (back) side pins of this connector are arranged in two rows. Unplug the cable from the connector and check inside the male connector for corrosion or bent pins. Replace cable when check is complete.

IMPORTANT NOTE: A regular meter probe does not penetrate deep enough to make a connection. Do NOT use a paper clip or you may damage the connector.

e) Clip one meter lead to a metal object small enough to fit *loosely* into the holes of the connector. This will be used as our 'probe'. Count to the indicated female pin (see table, next page) and stick the 'probe' into it.

f) Place the second meter lead on the matching numbered pin (see table, next page) on the solder side of the connector. A good connection will measure 10Ω or less.



CARD CAGE

ACTUATOR BOARD, P2 CABLE, PIN IDENTIFICATION (PUMPS)

PUMP	P2 PIN #	P2 LOCATION
DEAERATION PUMP (1 of 2)	15	Bottom row, 8 pins from rear
DEAERATION PUMP (2 of 2)	16	Top row, 8 pins from rear
FLOW PUMP (1 of 2)	19	Bottom row, 10 pins from rear
FLOW PUMP (2 of 2)	20	Top row, 10 pins from rear
ACID PUMP (1 of 4)	1	Bottom row, first pin from rear
ACID PUMP (2 of 4)	2	Top row, first pin from rear
ACID PUMP (3 of 4)	3	Bottom row, 2 pins from rear
ACID PUMP (4 of 4)	4	Top row, 2 pins from rear
BICARB PUMP (1 of 4)	5	Bottom row, 3 pins rom rear
BICARB PUMP (2 of 4)	6	Top row, 3 pins from rear
BICARB PUMP (3 of 4)	7	Bottom row, 4 pins from rear
BICARB PUMP (4 of 4)	8	Top row, 4 pins from rear
UF PUMP (1 of 4)	23	Bottom row, 12 pins from rear
UF PUMP (2 of 4)	24	Top row, 12 pins from rear
UF PUMP (3 of 4)	25	Bottom row, 13 pins from rear
UF PUMP (4 of 4)	26	Top row, 13 pins from rear

ACTUATOR BOARD, P2 CABLE, PIN IDENTIFICATION (VALVES)

VALVE	P2 PIN#	P2 LOCATION
24	29	Bottom row, 11 pins from front
41 (27)	32	Top row, 10 pins from front
43	46	Top row, 3 pins from front
39	44	Top row, 4 pins from front
29	34	Top row, 9 pins from front

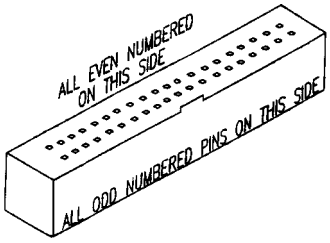
SECTION 17 - CHECKING THE SENSOR BOARD CABLE

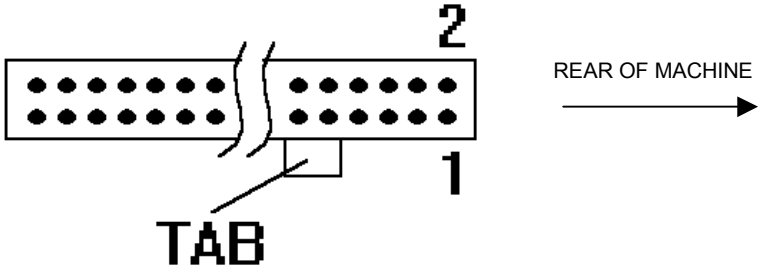
a) Turn the POWER OFF and unplug the smaller sensor board cable from the distribution board (SENSORS CONNECTOR).

b) Using a flashlight, check inside the male connector for bent or broken pins. Check also for signs of corrosion.

c) Check the female cable end for signs of corrosion. The cable ends are arranged in two rows, even in one row, odd in the other. The TAB identifies the 'odd' row.

FEMALE CONNECTOR



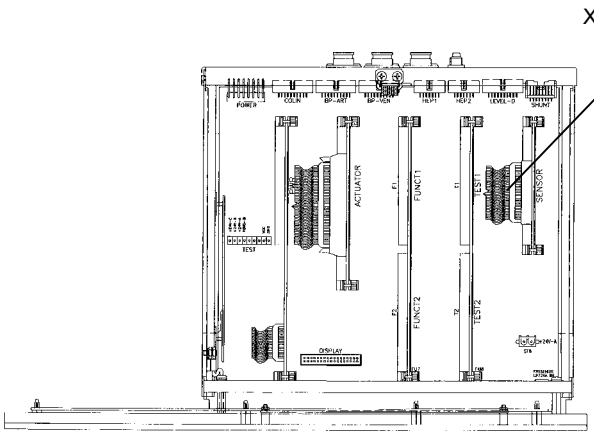


d) Inside the card cage the cable terminates at connector X2 (sensor board). The solder (back) side pins of this connector are arranged in two rows. Unplug the cable from the connector and check inside the male connector for corrosion or bent pins. Replace cable when check is complete.

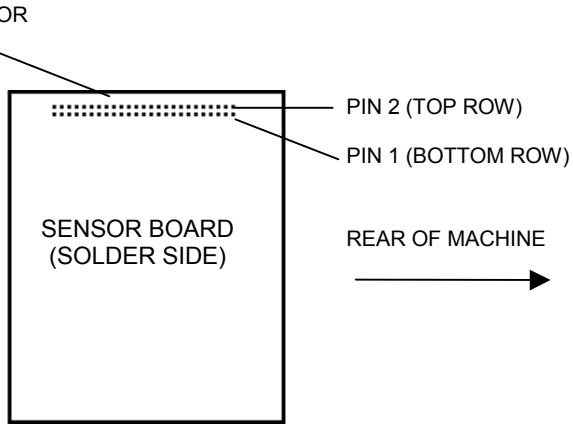
IMPORTANT NOTE: A regular meter probe does not penetrate deep enough to make a connection. Do NOT use a paper clip or you may damage the connector.

e) Clip one meter lead to a metal object small enough to fit *loosely* into the holes of the connector. This will be used as our 'probe'. Count to the indicated female pin (see table, next page) and stick the 'probe' into it.

f) Place the second meter lead on the matching numbered pin (see table, next page) on the solder side of the connector. A good connection will measure 10 Ω or less.



CARD CAGE



SENSOR BOARD, x2 CABLE, PIN IDENTIFICATION

DEVICE	x2 PIN #	x2 LOCATION
NTC-3	12	Top row, 6 pins from rear
NTC-2	13	Bottom row, 7 pins from rear
FLOAT	21	Bottom row, 7 pins from front
CFS TRANSDUCER (1 of 3)	11	Bottom row, 6 pins from rear
CFS TRANSDUCER (2 of 3)	14	Top row, 7 pins from rear
CFS TRANSDUCER (3 of 3)	15	Bottom row, 8 pins from rear
COND CELL	16	Top row, 8 pins from rear
ACID EOS	25	Bottom row, 5 pins from front
BICARB EOS	23	Bottom row, 6 pins from front
AIR SENSOR	5	Bottom row, 3 pins from rear
BLOOD LEAK DETECTOR TEST	2	Top row, first pin from rear
BLOOD LEAK DETECTOR SENSOR	4	Top row, 2 pins from rear
BLOOD LEAK DETECTOR DIMNESS	3	Bottom row, 2 pins from rear
BLOOD LEAK DETECTOR OUTPUT	6	Top row, 3 pins from rear
DIALYSATE TRANSDUCER (1 of 3)	8	Top row, 4 pins from rear
DIALYSATE TRANSDUCER (2 of 3)	10	Top row, 5 pins from rear
DIALYSATE TRANSDUCER (3 of 3)	11	Bottom row, 6 pins from rear

SECTION 18 - MANUAL BALANCING CHAMBER VALVE LEAK TESTS

A. These tests should be run if the automated valve leak tests have not indicated a problem but you still suspect a leaking balancing chamber valve.

B. These tests require intensive work inside the distribution board, plugging and unplugging valves and pumps. Be CAREFUL.

NOTE: Reference is to the HYDRAULIC FLOW DIAGRAM

BC- 1.0.0 TESTING BOTTOM VALVES ('FRESH SIDE' PRESSURIZED)

a) Turn the machine off and clamp the clear input tubing at VALVE 30 (see diagram below).

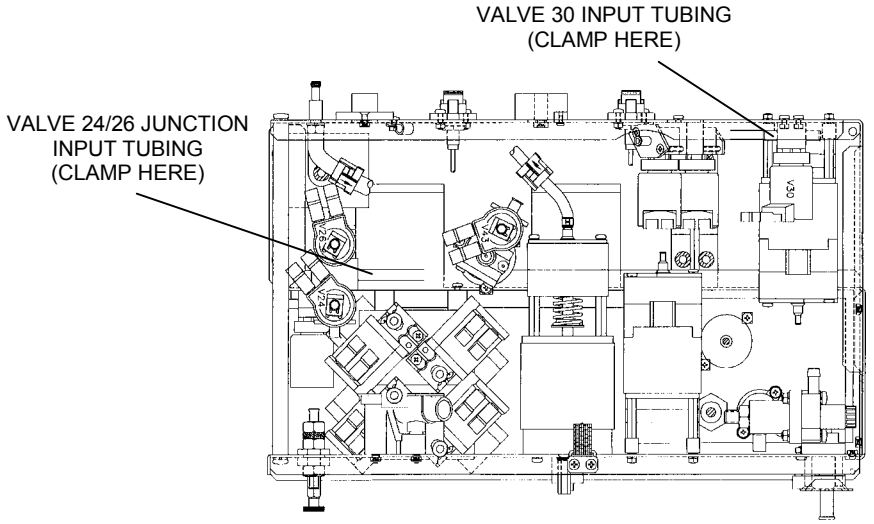
b) Turn the machine on and push the SET button only ONCE. WARNING! Do NOT enter DIALYZE mode.

NOTE: When the VERIFY CONCENTRATE message is up on the screen all top balancing chamber valves are all open while all bottom valves are closed. Also, the deaeration pump runs continuously which pressurizes 'fresh side' valves 35 and 37.

c) From VERIFY CONCENTRATE call up debug screen 9. PDIA should initially read approximately 5 vdc. Monitor it for two minutes. Is PDIA STEADILY decreasing towards 0 vdc? IGNORE UP AND DOWN FLUCTUATIONS.

Yes A leak is indicated at valve 35 or 37. See BC- 1.0.1

No See BC- 2.0.0



BC- 1.0.1 LOCATING THE LEAK

a) Clamp the clear tubing at balancing chamber valve 32 (see REAR VIEW diagram, page 32) and turn the power off.

b) Turn the power back on and push the SET button only ONCE.

WARNING! Do NOT enter DIALYZE mode.

c) From VERIFY CONCENTRATE call up debug screen 9. Is PDIA still decreasing STEADILY? IGNORE UP AND DOWN FLUCTUATIONS.

Yes Valve 37 is leaking

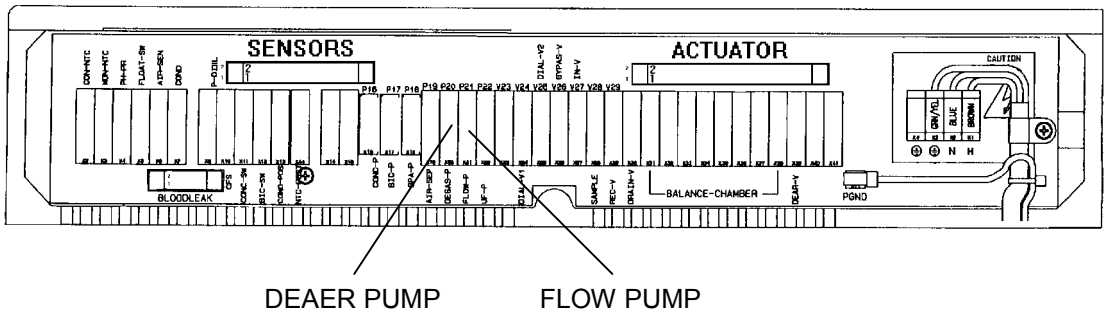
No Valve 35 is leaking.

BC- 2.0.0 TESTING BOTTOM VALVES ('SPENT SIDE' PRESSURIZED)

a) Remove the clamp from valve 30 and clamp the clear input tubing at the valve 24/26 JUNCTION BLOCK (see diagram, previous page).

b) Turn the heater breaker switch off ("0" pushed down, see diagram A, page 5).

c) Plug the flow pump distribution board connector (P21, FLOW-P) into the deaeration pump's position (P20, DEGAS-P), leaving the deaeration pump unplugged. This makes the flow pump run to pressurize 'spent side' valves 36 and 38.



d) Monitor PDIA for two minutes. Is it STEADILY increasing towards 10 vdc? IGNORE UP AND DOWN FLUCTUATIONS.

Yes A leak is indicated at valve 36 or 38. See BC- 2.0.1

No See BC- 3.0.0

BC- 2.0.1 LOCATING THE LEAK

a) Clamp the clear tubing at valve 32 (see REAR VIEW diagram, page 32) and turn the power off.

b) Turn the power back on and push the SET button only ONCE. **WARNING!** Do NOT enter DIALYZE mode.

c) From VERIFY CONCENTRATE call up debug screen 9. Is PDIA still increasing STEADILY? IGNORE UP AND DOWN FLUCTUATIONS.

Yes Valve 38 is leaking.

No Valve 36 is leaking.

BC- 3.0.0 TESTING VALVE 32 ('SPENT SIDE' PRESSURIZED)

a) Plug valve 36 into 32's position and vica versa.

b) Monitor PDIA for two minutes. Is it STEADILY increasing towards 10 vdc? IGNORE UP AND DOWN FLUCTUATIONS.

Yes Valve 32 is leaking.

No Plug the valves back in correctly and see BC- 3.0.1

BC- 3.0.1 TESTING VALVE 34 ('SPENT SIDE' PRESSURIZED)

a) Plug valve 38 into 34's position and vica versa.

b) Monitor PDIA for two minutes. Is it STEADILY increasing towards 10 vdc? IGNORE UP AND DOWN FLUCTUATIONS.

Yes Valve 34 is leaking.

No Plug the valves back in correctly and see BC- 4.0.0

BC- 4.0.0 TESTING VALVE 31 ('FRESH SIDE' PRESSURIZED)

a) Remove the clamp from the valve 24/26 junction block and clamp at valve 30 again.

b) Plug the pumps back into their proper positions (P20, DEGAS-P) (P-21, FLOW-P). The deaeration pump now runs to pressurize the 'fresh side' of the balancing chambers.

c) Plug valve 35 into 31's position (V31), and vica versa.

d) Monitor PDIA for two minutes. Is it STEADILY decreasing towards 0 vdc? IGNORE UP AND DOWN FLUCTUATIONS.

Yes Valve 31 is leaking.

No Plug the valves back in correctly and see BC- 4.0.1

BC- 4.0.1 TESTING VALVE 33 ('FRESH SIDE' PRESSURIZED)

a) Plug valve 37 into 33's position and vica versa.

b) Monitor PDIA for two minutes. Is it STEADILY decreasing towards 0 vdc? IGNORE UP AND DOWN FLUCTUATIONS.

Yes Valve 33 is leaking

No Plug the valves in correctly. A leak is not indicated using this test.

SECTION 19 - TESTING FOR A LEAKING BALANCING CHAMBER DIAPHRAGM

This test uses BALANCING CHAMBER VOLUME CALIBRATIONS in an attempt to locate a leaking balancing chamber (BC) diaphragm. There are two parts, collecting volumes from the fresh and spent sides of the diaphragm. For accurate measurements use a dry 100 ml graduated cylinder for each part.

Prior to beginning assure that there are no leaking BC valves using DIAGNOSTICS/VALVE LEAK TEST.

PART I CHECKING THE FRESH SIDE

a) Loosen the drain hose from the drain port at the back of the machine (don't remove it yet).

b) Place the machine into service mode and enter CALIBRATION/BAL CHAMBER VOLUME.

c) The screen displays: BAL CHAMBER VOLUME
OPTIONAL PRIMING?

d) Push the prime button and allow it to run for 30 seconds.

e) Stop prime and push SET.

The screen displays: BAL CHAMBER VOLUME
PREPARING TO PRIME

Followed by: BAL CHAMBER VOLUME
PRIMING

Followed by: BAL CHAMBER VOLUME
PREPARING TO CALIBRAT

f) You have 25 seconds to remove the drain hose from the port and prepare to collect the fluid output from it with the cylinder. Two cycles will be automatically dispensed. If spillage occurs start over! Collected volume should = the value on the screen. Do NOT change screen values!! Any discrepancy (to the high side) may indicate a leaking BC diaphragm.

Theory: The deaeration pump loads the balancing chamber with fresh dialysate at 19 psi displacing spent to the drain (at 0 mmHg). High pressure on the fresh side of the diaphragm may result in higher volumes to the drain if the BC diaphragm is torn.

PART II CHECKING THE SPENT SIDE

a) Connect the drain line back to the machine and push RESET to return to the main CALIBRATION menu.

b) Repeat above procedure until the message "PREPARING TO CALIBRAT" appears. You have 25 seconds to remove red and blue hansen connectors from the shunt, put the red hansen into a bucket of water and stand ready to collect the two-cycle output, from blue hansen, into the cylinder. If spillage should occur start over! Collected volume should = the value on the screen. Any discrepancy (to the high side) may indicate a leaking BC diaphragm.

Theory: The flow pump fills the balancing chamber with spent dialysate (at about 12 psi) displacing fresh into the venous dialysate line which is now at 0 mmHg. The higher pressure on the spent side of the diaphragm may result in higher volumes into the venous line if the diaphragm is torn.

NOTES:

NOTES:

NOTES:

COMMON CONVERSIONS

PRESSURE

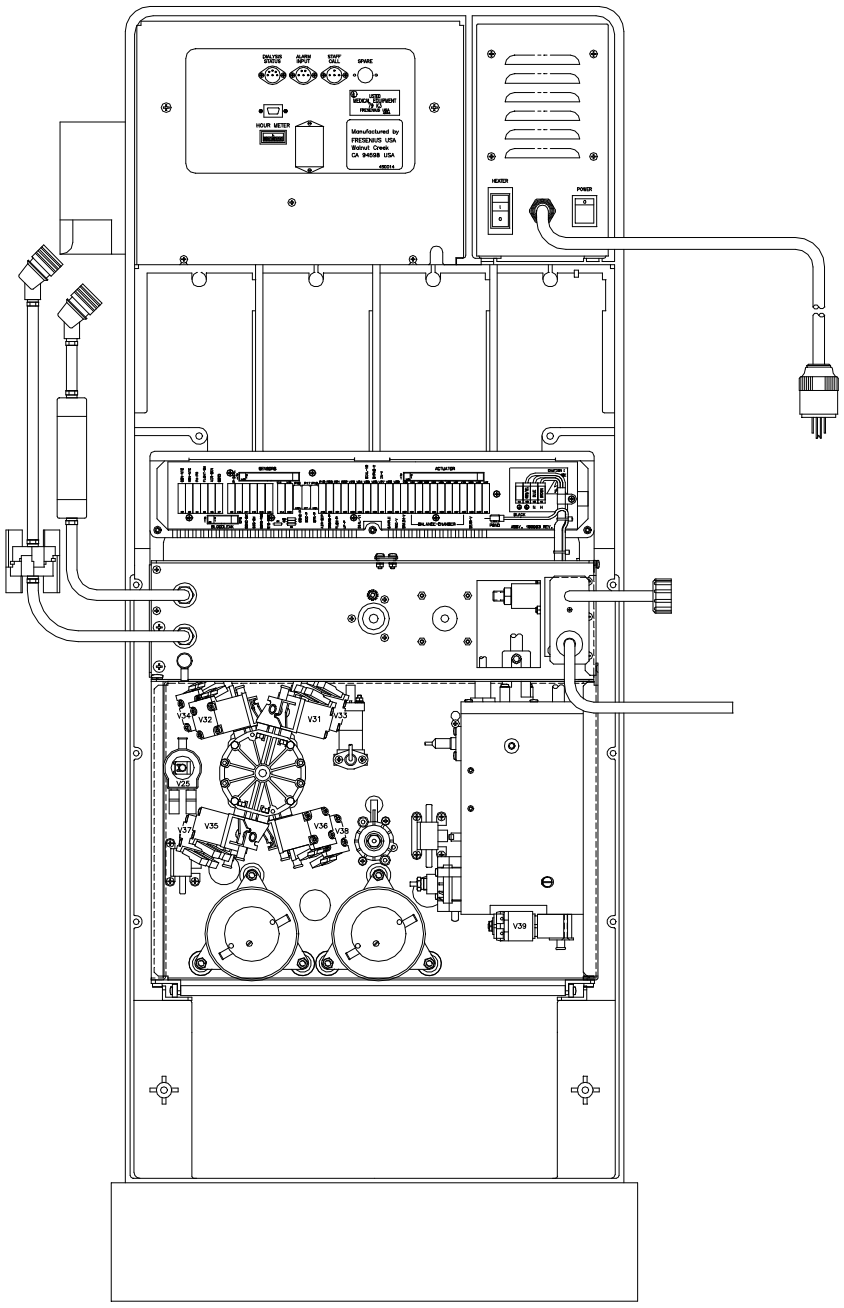
1 Bar	29.53 inHg
1 inHg	25.4 mmHg
1 Psi	51.72 mmHg

VOLUME

1 FLUID OUNCE	26.6 MILLILITERS
1 U.S QUART	0.946 LITERS
1 U.S. GALLON	3.8 LITERS
0.034 FLUID OUNCES	1 MILLILITER
1.057 QUARTS	1 LITER
0.26 U.S. GALLON	1 LITER

MASS

1 OUNCE (avdp.)	28.35 GRAMS
1 POUND (avdp.)	0.45 KILOGRAM
0.035 OUNCE (avdp.)	1 GRAM



FRESENIUS USA, INC.
2637 SHADELANDS Drive
Walnut Creek, CA 94598
800 227-2572

REV	ECO #	BY	DATE	CHK	REVISION
A	6848	BH	7.22.99	JEF	RELEASE

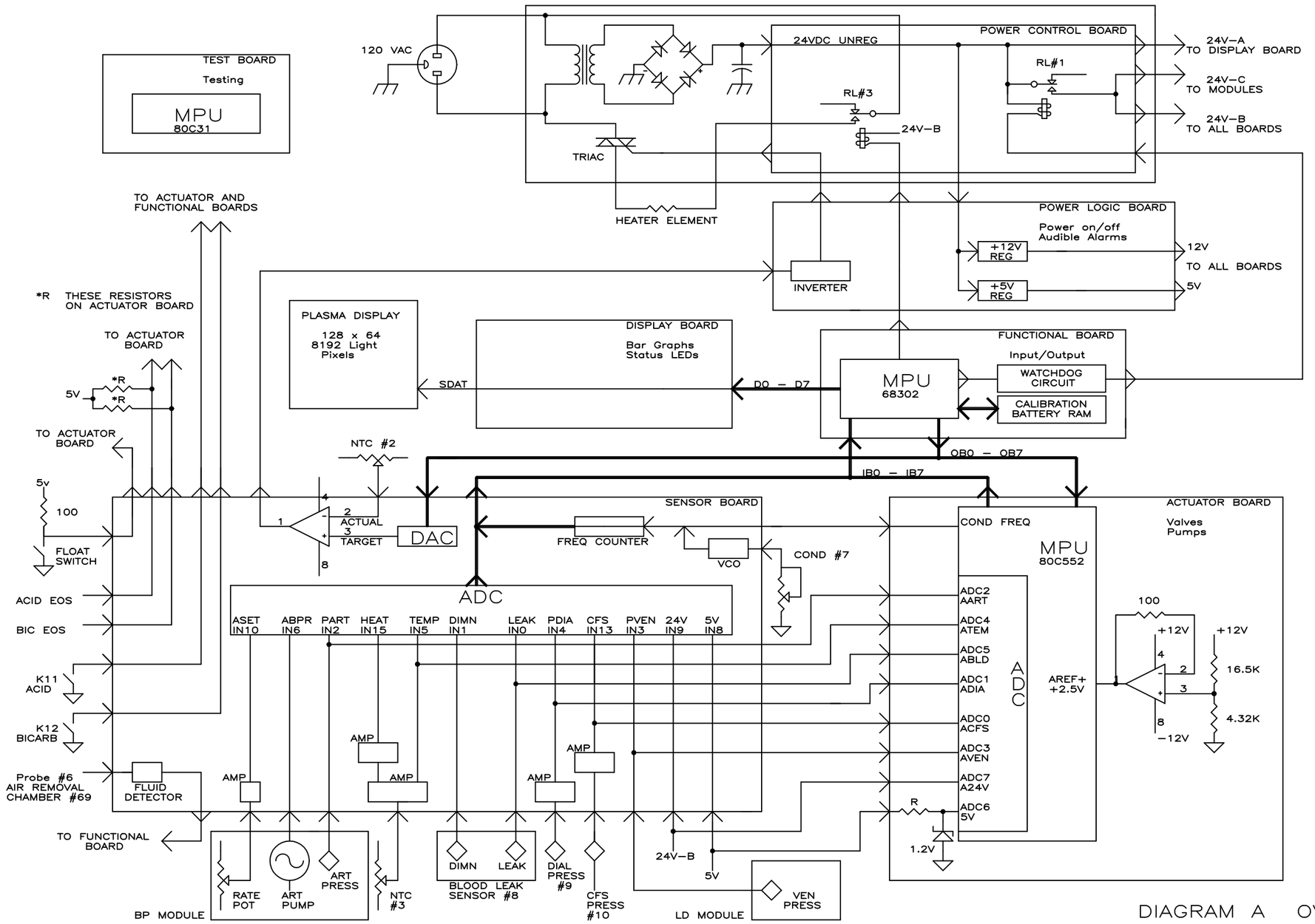


DIAGRAM A OVERALL

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	DATE	NAME
DRAWN	3.25.99	B. LEPARD

MATERIAL

2008H ELECTRONIC BLOCK DIAGRAM

SCALE NONE

FRESENIUS

290143

REV. A

SHEET 1 OF 10

O:\ACAD\2\290143-1.DWG

REV	ECO #	BY	DATE	CHK	REVISION
A	6848	BH	7.22.99	JEF	RELEASE

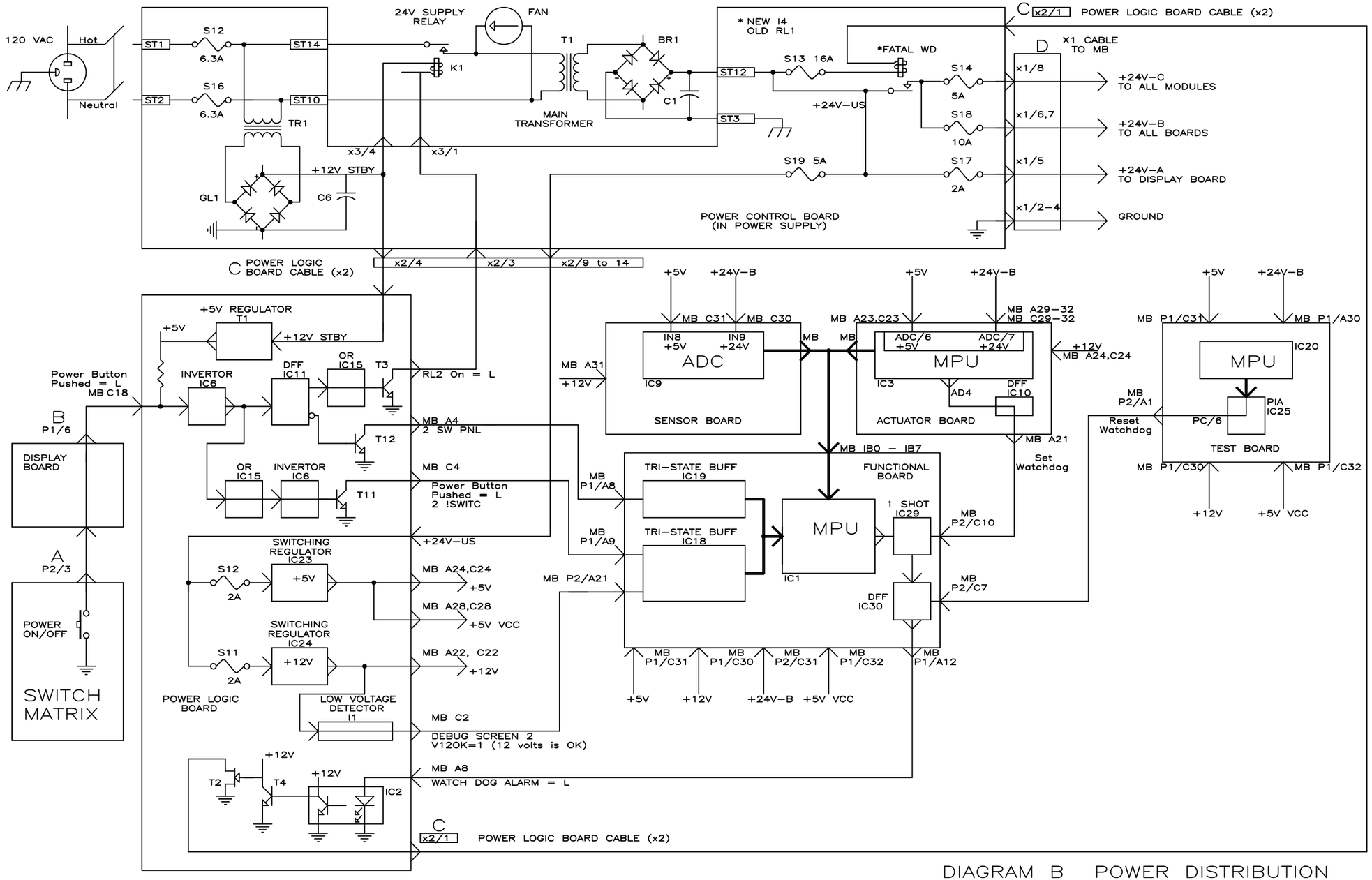

DIAGRAM B POWER DISTRIBUTION

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	DATE	NAME
DRAWN	3.25.99	B. LEPARD

MATERIAL

2008H ELECTRONIC BLOCK DIAGRAM

SCALE NONE

FRESENIUS

290143

REV. A

SHEET 2 OF 10

O:\ACAD\2\290143–2.DWG

REV	ECO #	BY	DATE	CHK	REVISION
A	6848	BH	7.22.99	JEF	RELEASE

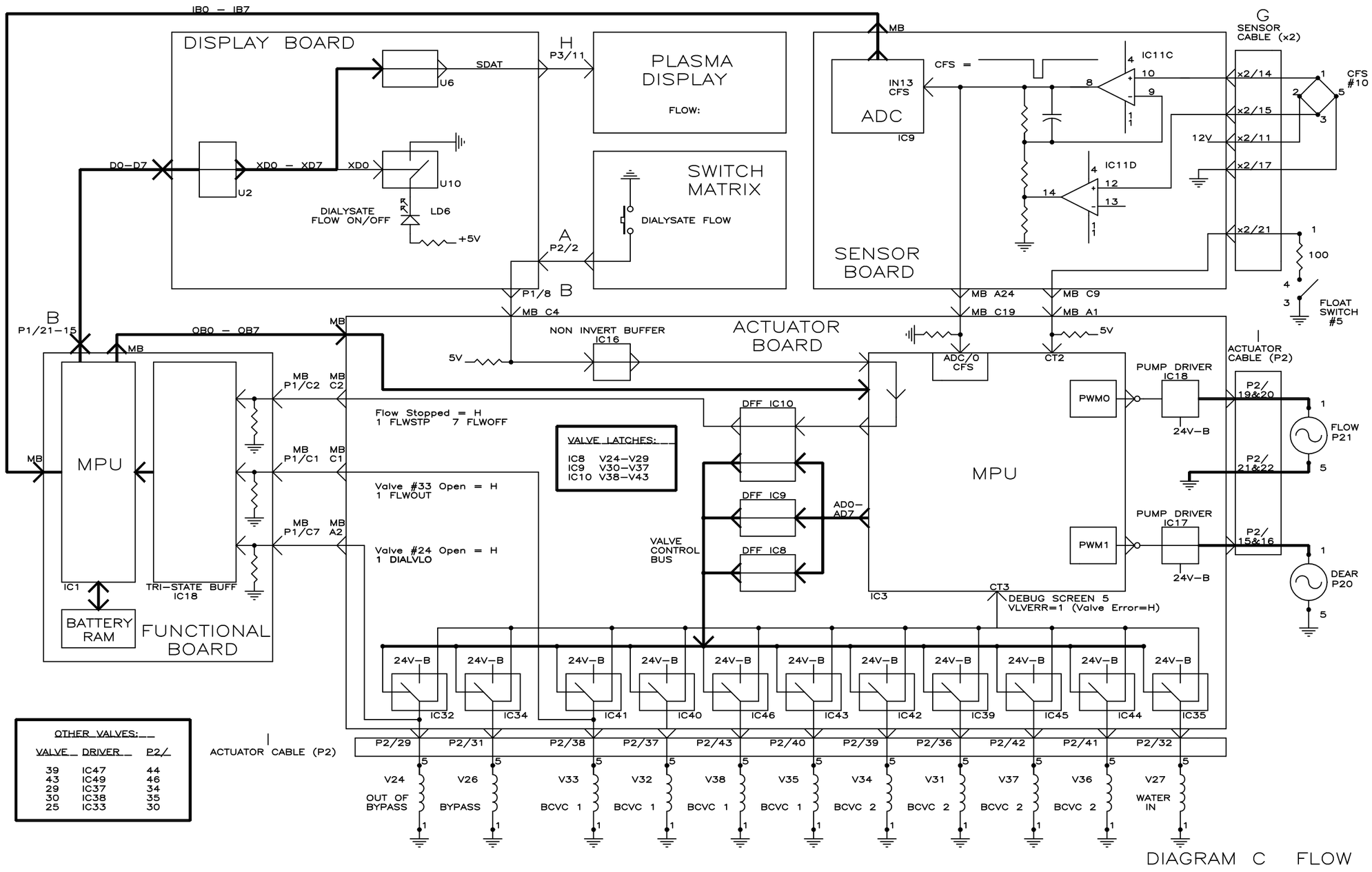

DIAGRAM C FLOW

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MATERIAL

2008H ELECTRONIC BLOCK DIAGRAM

SCALE NONE

FRESENIUS

290143

REV. A

SHEET 3 OF 10

O:\ACAD\2\290143-3.DWG

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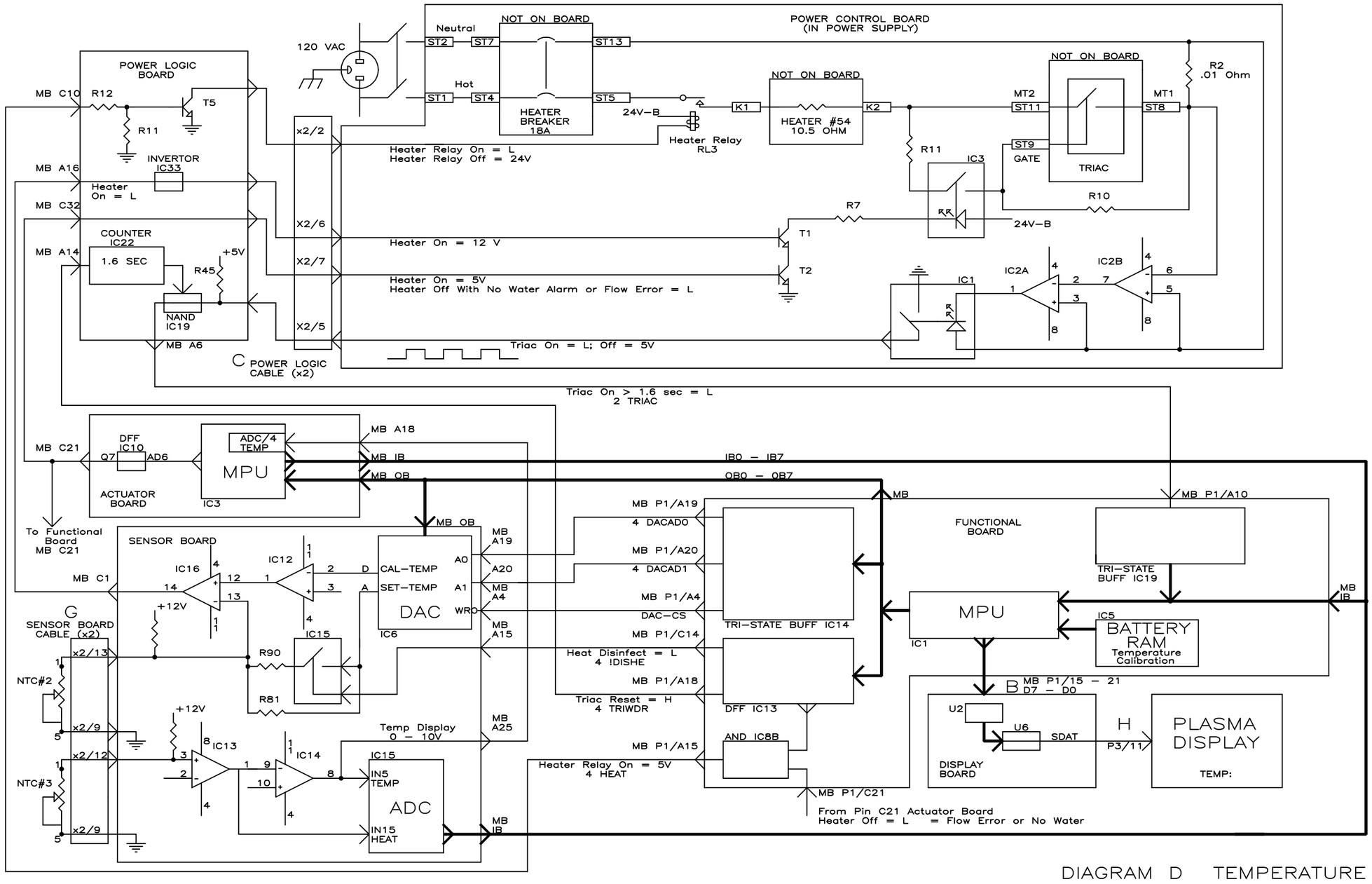

DIAGRAM D TEMPERATURE

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	DATE	NAME
DRAWN	3.25.99	B. LEPARD

MATERIAL

FRESENIUS

2008H ELECTRONIC BLOCK DIAGRAM

SCALE NONE

290143

REV. A

SHEET 4 OF 10

O:\ACAD\2\290143-4.DWG

REV	ECO #	BY	DATE	CHK	REVISION
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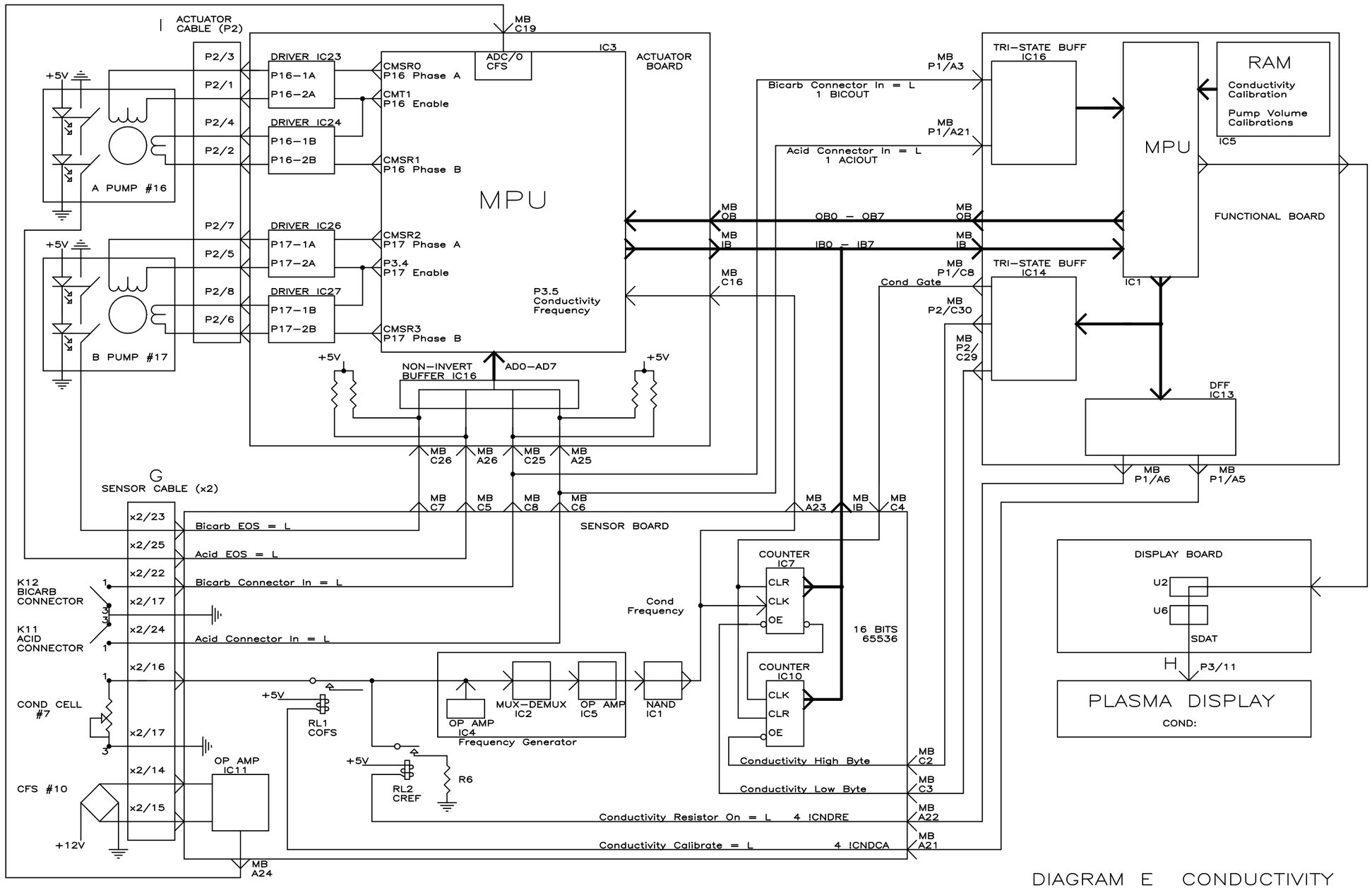

DIAGRAM E CONDUCTIVITY

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MATERIAL

2008H ELECTRONIC BLOCK DIAGRAM

SCALE NONE

FRESENIUS

290143

REV. A

O:\ACAD\2\290143-5.DWG

SHEET 5 OF 10

REV	ECO #	BY	DATE	CHK	REVISION
A	6848	BH	7.22.99	JEF	RELEASE

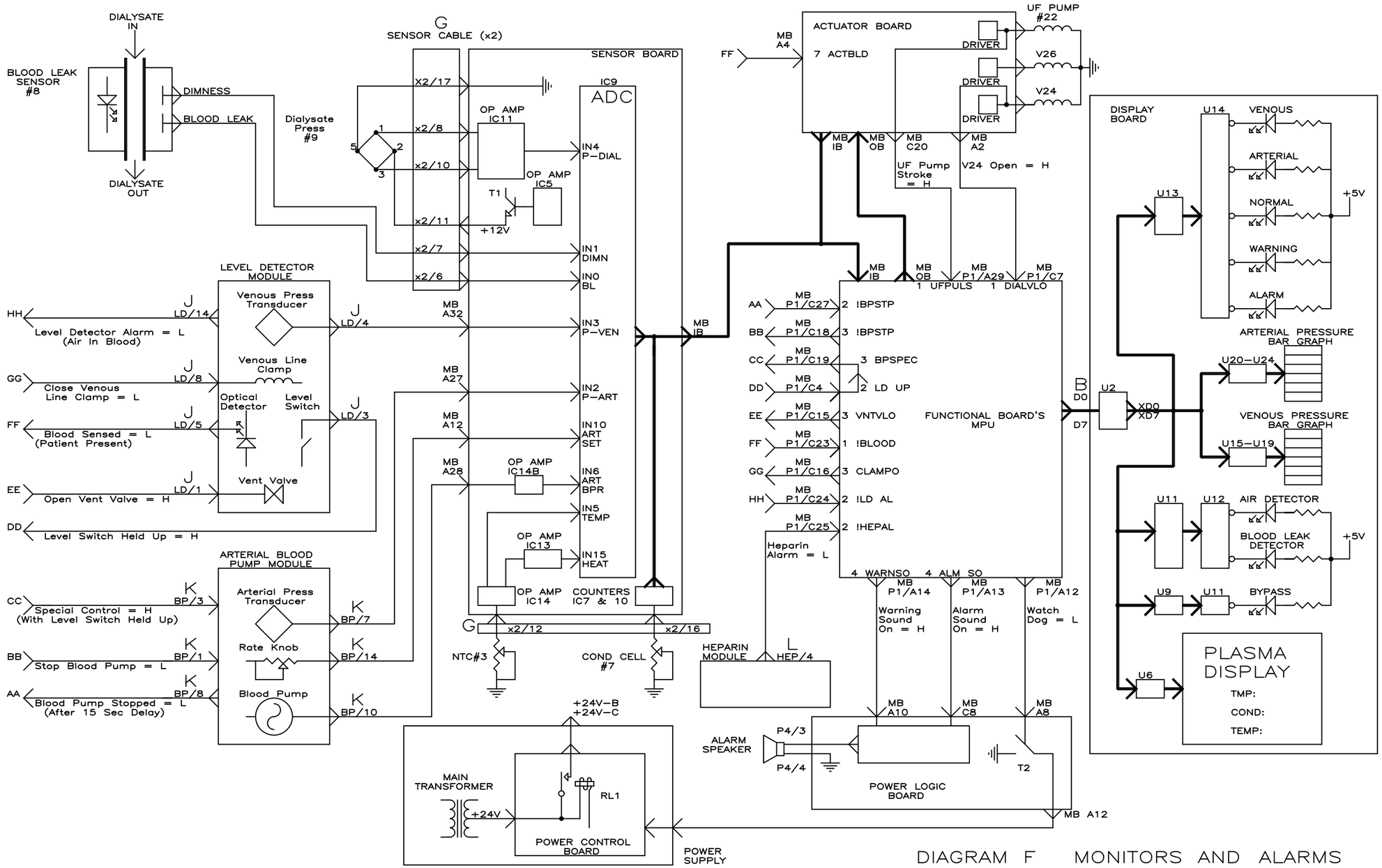

DIAGRAM F MONITORS AND ALARMS

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	DATE	NAME
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MATERIAL

2008H ELECTRONIC BLOCK DIAGRAM

SCALE NONE

FRESENIUS

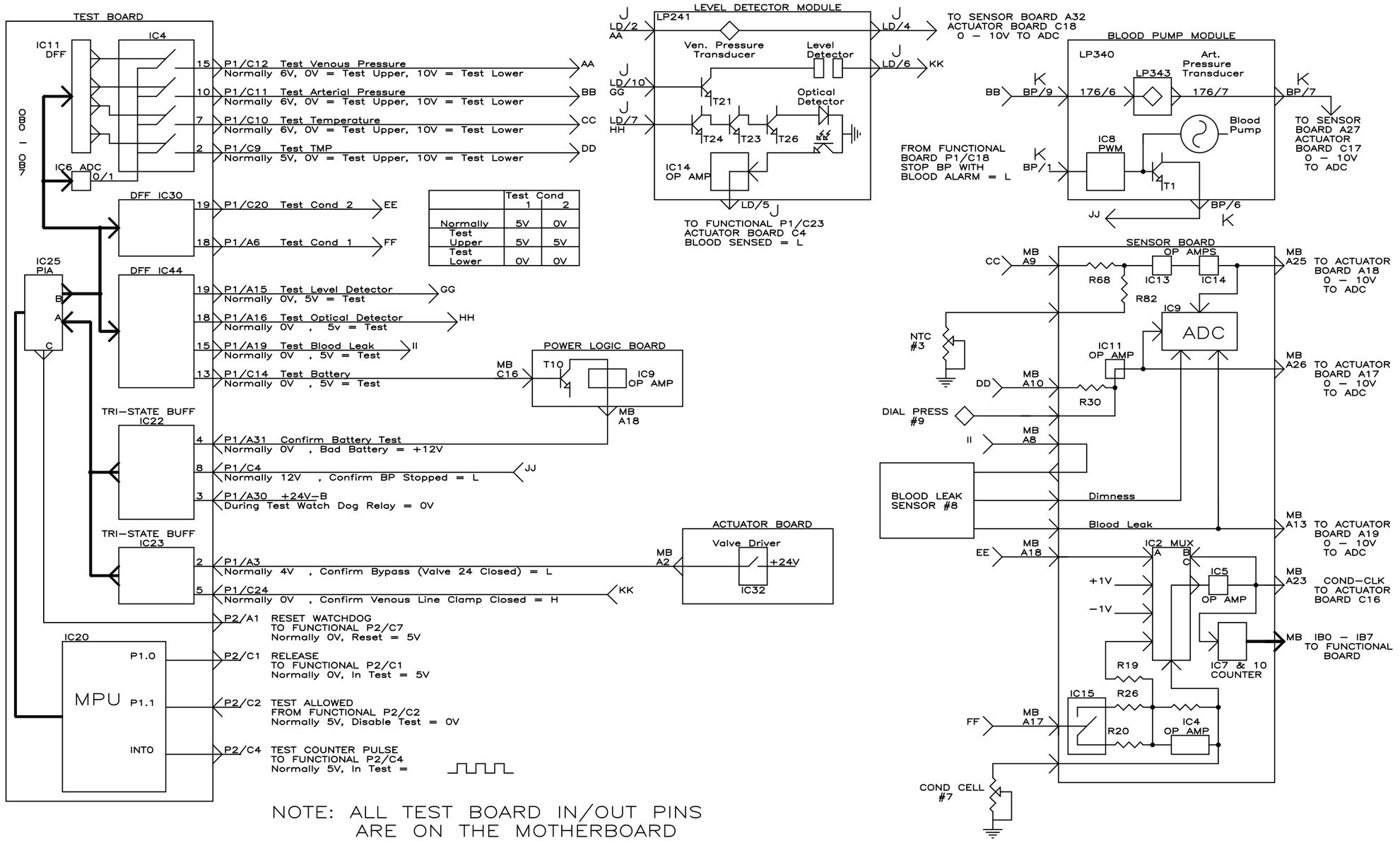
290143

REV. A

SHEET 6 OF 10

O:\ACAD\2\290143-6.DWG

REV	ECO #	BY	DATE	CHK	REVISION
A	6848	BH	7.22.99	JEF	RELEASE



NOTE: ALL TEST BOARD IN/OUT PINS ARE ON THE MOTHERBOARD

DIAGRAM G TESTING

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MATERIAL

2008H ELECTRONIC BLOCK DIAGRAM

SCALE NONE

FRESENIUS

290143

REV. A

SHEET 7 OF 10

O:\ACAD\2\290143-7.DWG

REV	ECO #	BY	DATE	CHK	REVISION
A	6848	BH	7.22.99	JEF	RELEASE

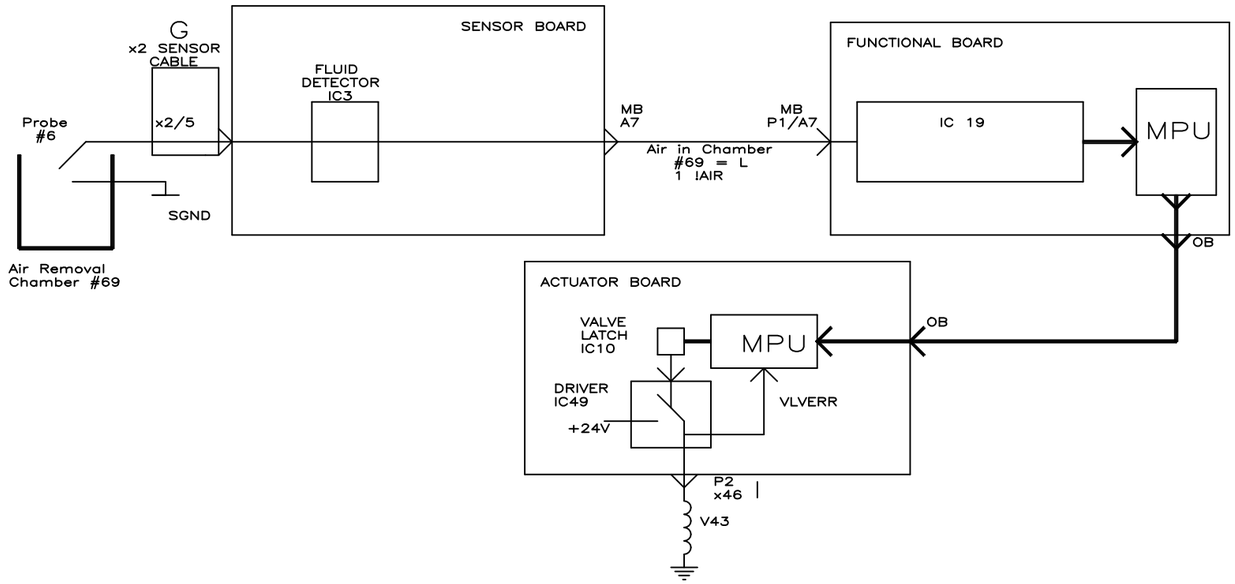

DIAGRAM H FILL PROGRAM

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MATERIAL

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290143

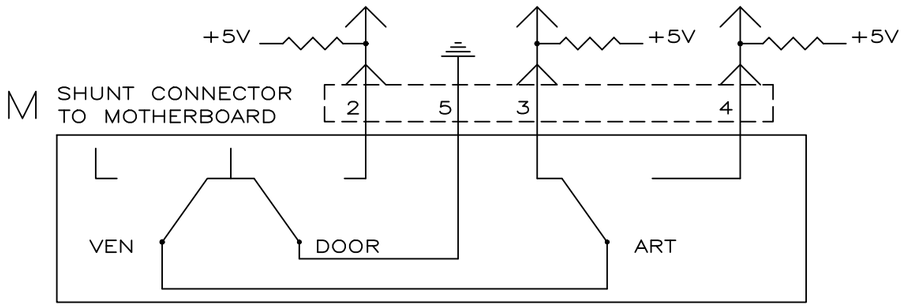
REV. A

O:\ACAD\2\290143-8.DWG

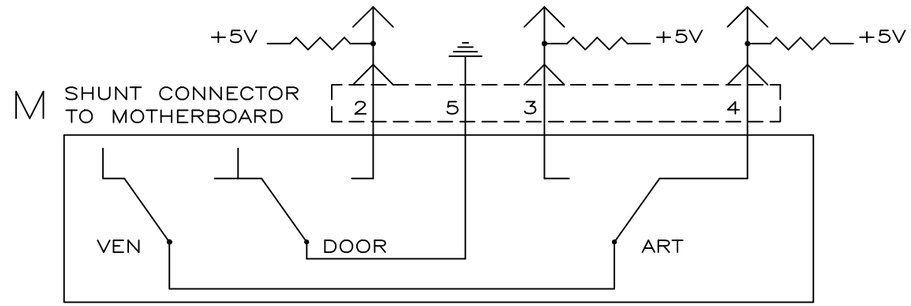
SHEET 8 OF 10

REV	ECO #	BY	DATE	CHK	REVISION
A	6848	BH	7.22.99	JEF	RELEASE

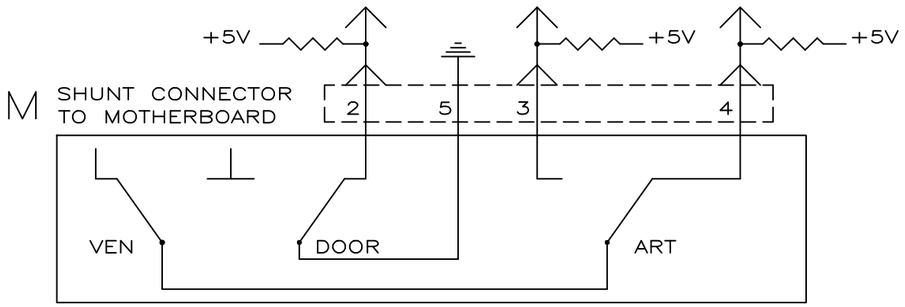
CONNECTOR P8 TO MOTHERBOARD
Pin 1 = Not Connected
Pin 2 = To functional board P1/C6, actuator board C6
Pin 3 = To functional board P1/A30, actuator board A5
Pin 4 = To functional board P1/A31, actuator board C5
Pin 5 = Ground



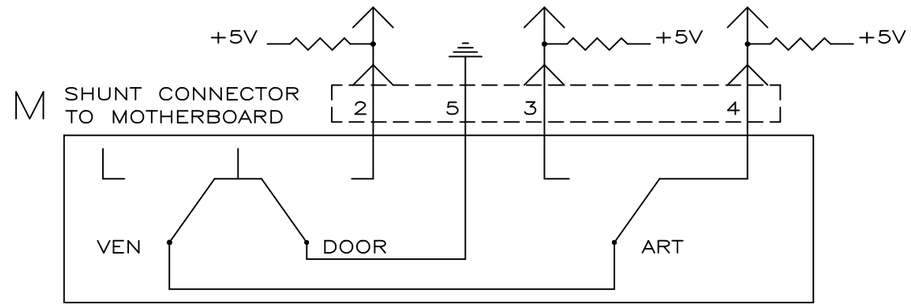
Both lines in shunt; shunt door closed
Pin 2 = +5V (Door closed)
Pin 3 = 0V (Both lines in shunt)
Pin 4 = +5V (Emptying not active)



Neither line in shunt; shunt door closed
Pin 2 = +5V (Door closed)
Pin 3 = +5V (Both dialysate lines not in)
Pin 4 = +5V (Emptying not active)



Shunt door open
Pin 2 = 0V (Door open)
Pin 3 = +5V (Both dialysate lines not in)
Pin 4 = +5V (Emptying not active)



Venous line in shunt, arterial line not in, shunt door closed
Pin 2 = +5V (Door closed)
Pin 3 = +5V (Venous line in, arterial line not in)
Pin 4 = 0V (Emptying activated)

DIAGRAM I SHUNT DOOR SWITCH CONFIGURATIONS

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REV. A
SHEET 9 OF 10

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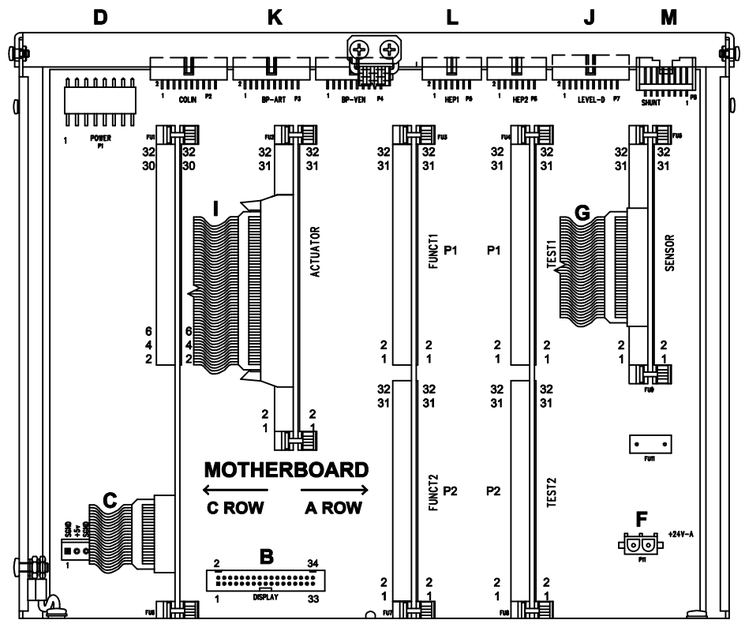
REV	ECO #	BY	DATE	CHK	REVISION
A	6848	BH	7.22.99	JEF	RELEASE

CARD CAGE
LEFT TO RIGHT:
POWER LOGIC BOARD
ACTUATOR BOARD
FUNCTIONAL BOARD
TEST BOARD
SENSOR BOARD



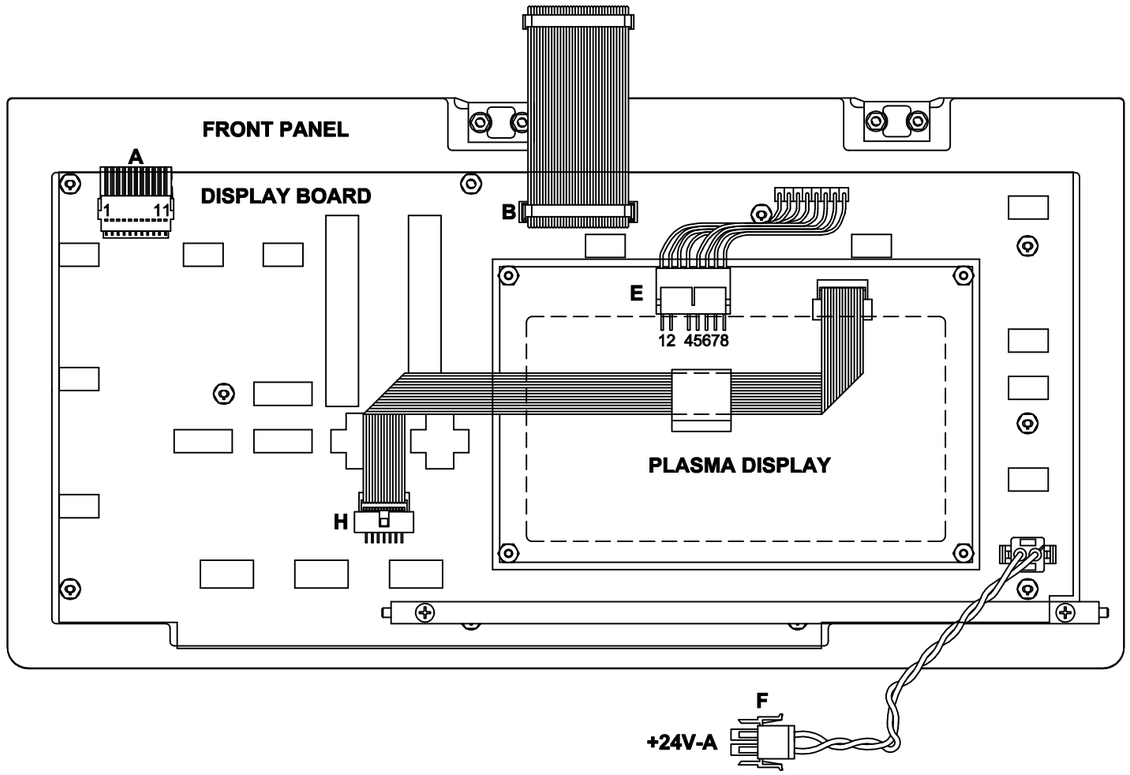


DIAGRAM J CARD CAGE AND DISPLAY BOARD

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SCALE NONE

FRESENIUS

290143

REV. A
SHEET 10 OF 10

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S E C T I O N V I I I

MAINTENANCE

ROUTINE MAINTENANCE PROCEDURES

8.0.1. Clean Filter Screen

Frequency: Monthly, or as required.

Rationale: To avoid restriction of water flow to 2008H machine.

Steps:
#1 Turn off power and water supply, and disconnect water hose.

#2 Remove washer filter screen.

#3 Rinse screen thoroughly in water to remove debris.

#4 Insert screen and reconnect water hose to water outlet.

NOTE: The inlet water hose and filter should be disinfected on a regular basis as frequently as the R.O. and associated plumbing are done in your facility. This is achieved by placing the 2008H in the "Rinse" mode during RO Disinfection procedure.

8.0.2. Replacement of Water Inlet Filter 63 (if present)

Frequency: Monthly

Rationale: To avoid restriction of water flow to 2008H and the accumulation of water contaminates.

Steps:
#1 Turn power and water off to 2008H.

#2 Vent pressure to filter housing with vent release at bottom of housing.

#3 Remove filter housing and filter cartridge.

#4 Replace with new filter and replace housing. Close vent release at bottom of filter housing.

#5 Turn power "On" and water on to 2008H. Place the "Rinse" mode and check filter housing for visible leaks.

NOTE: The inlet water hose should be disinfected on a regular basis as frequently as the R.O. and associated plumbing is done in your facility. This is achieved by placing the 2008H in the "Rinse" mode during RO Disinfection procedure.

8.0.3. Acetic acid (5%) rinse (White distilled vinegar)

Frequency: Daily

Rationale: To minimize precipitate build up in Bicarbonate Dialysis.

Steps:

#1 Place dialysate hoses on interlock after patient treatments are discontinued for the day.

#2 Leave red suction nozzle attached to acid concentrate. Place blue concentrate suction nozzle in container of acetic acid (5%) white distilled vinegar.

CAUTION: Label machine "ACID FILLED"

#3 Press "ACID CLEAN" and allow uptake of vinegar for at least 5—10 minutes.

#4 Place red and blue suction nozzles in Rinse ports. A hot water rinse may be used to rinse and disinfect the 2008H by selecting HEAT DISINFECT. Allow the machine to complete the "Heat Disinfect" cycle.

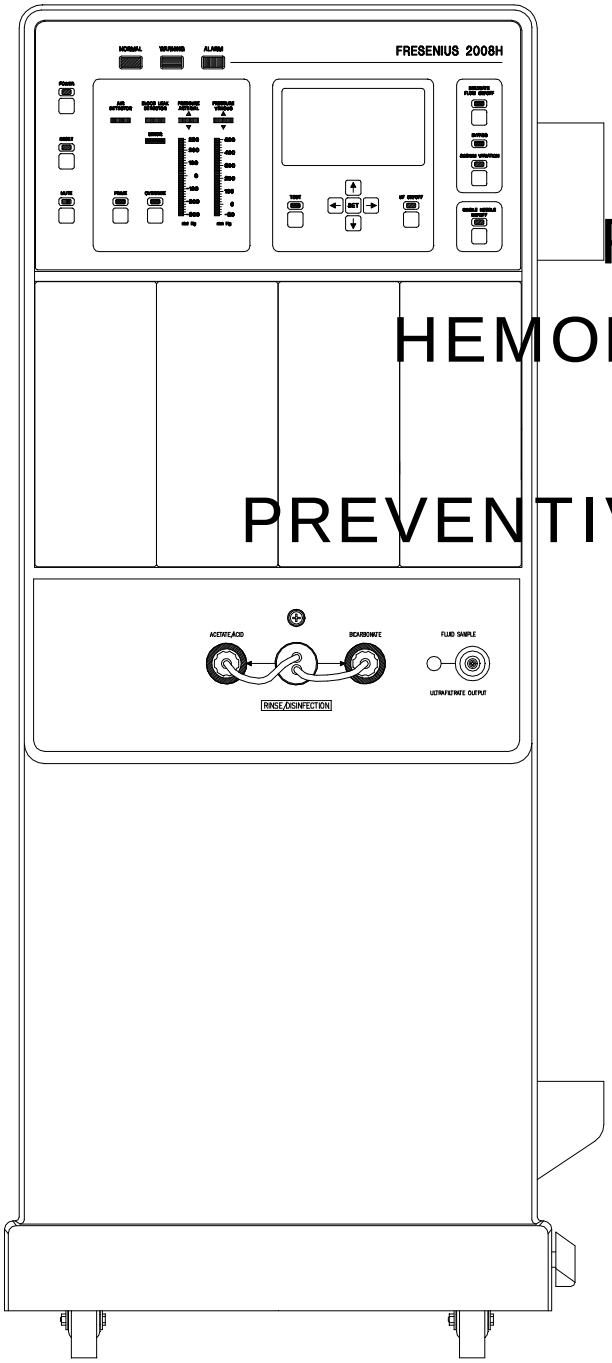
#5 When "Heat Disinfect" is completed, turn machine and associated water feed valve off.

#6 Check with the pH and conductivity before initiating dialysis.

WARNING: This is an alternate procedure that bypasses a mandatory rinse cycle. Operator must follow above steps accurately.

NOTE: If "Chemical Disinfect" is desired after "Acid Clean", the "Rinse" cycle must be completed before initiating "Chemical Disinfection".

WARNING: The rinse cycle must be completed before the dialysis machine is used for a patient treatment. Test the dialysate for proper pH and conductivity.



FRESENIUS 2008H HEMODIALYSIS SYSTEM

PREVENTIVE MAINTENANCE PROCEDURES

Part Number 500558 Rev. F

FRESENIUS USA, INC.

2637 Shadelands Drive, Walnut Creek, CA 94598

800-227-2572 or 925-295-0200

REGIONAL EQUIPMENT SPECIALIST: _____

FRESENIUS 2008H
HEMODIALYSIS SYSTEM

PREVENTIVE MAINTENANCE PROCEDURES

Part Number 500558 Rev. F

INCLUDING
PREVENTIVE MAINTENANCE CHECKLISTS
QUARTERLY/1000 HOUR AND ANNUAL/4000 HOUR

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WARNINGS

Shock hazard. Refer servicing to qualified personnel.

Failure to install, operate and maintain this equipment according to the manufacturer's instructions may cause patient or operator injury or death.

Never perform maintenance when a patient is connected to the machine. If possible, remove the machine from the treatment area when it is being serviced. Label the machine to ensure it is not accidentally returned to clinical use before the service work is completed. Always fully test the machine when maintenance is completed. Confirm dialysate conductivity and pH level before returning the machine to clinical use.

PREVENTIVE MAINTENANCE PROCEDURES
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NOTE

This document is written for Fresenius 2008H Hemodialysis Systems using software versions 8.02 or later.

1.0 INTRODUCTION

Preventive Maintenance for the Fresenius 2008H Hemodialysis System is simple and straightforward. Maintenance is performed in only two intervals: Quarterly or after 1000 hours of operation, and annually or after 4000 hours of operation. The maintenance procedures have been devised to require a minimum of time while ensuring that the machine is maintained in optimum operating condition.

Included in the Preventive Maintenance procedures are tests to verify normal machine operation. Should the machine fail to pass any of these tests, repair or re-calibrate as needed, then repeat the tests until the specifications are met before returning the machine to service.

Checklists are provided in the back of this manual to record the work done. Make copies of these checklists as needed. Your initials on the checklist certifies that each procedure has been completed and that the machine is performing according to the specifications given.

1.1 TEST EQUIPMENT AND SUPPLIES NEEDED

A number of small parts must be available to perform the Preventive Maintenance. Fresenius part number 190098 is a kit of the parts needed, except for the 9-Volt battery that must be replaced during the annual preventive maintenance. An NEDA 1604AC heavy-duty (alkaline type) battery is required. In addition, the following test equipment is needed:

WARNING

All of the test equipment used must be maintained and calibrated regularly in accordance with NIST standards. In particular, the conductivity meter must meet the specifications given below. Failure to do so could result in injury or death to the patient or to the operator.

WARNING

Disinfect the machine internally and externally and check all pressure transducer protectors for contamination before working on the machine.

- Fresenius Test Kit (part number 150034), which contains two gauges with fittings and hoses for measuring loading pressure and deaeration pressure.
- Dialysate meter to measure dialysate pressure, temperature and conductivity at the ends of the dialysate lines. The meter must be capable of making pressure measurements from -250 mmHg to +400 mmHg with an accuracy of at least ±2 mmHg up to ±200 mmHg and an accuracy of at least 1% and ±1 mmHg beyond ±200 mmHg. The temperature function of this meter must be accurate within 0.2°C from 20°C to 45°C and must be capable of measuring dialysate temperatures up to 85°C with an accuracy of at least ±4.0°C. The conductivity function of this meter must be accurate to within 0.1 mS over a range of 12 mS to 17 mS at a temperature of 25°C.
- Stopwatch with a resolution to 0.01 second and an accuracy of 0.01% or better.
- Fresenius Buret, 25 ml capacity with 0.1 ml graduations (Fresenius part number 290104).
- Graduated cylinder: 1000 ml capacity with a tolerance of 5.0 ml at 1000 ml or better.
- Syringe, 60 cc capacity. Tolerance is not important; the syringe is not used for volume measurements.
- Tubing, 24” long (Fresenius part number 545325).
- Tachometer capable of measuring shaft speeds up to 2900 rpm with an accuracy of ±3 rpm or better. The tachometer is not required, but is highly recommended to work efficiently.

For machines equipped with Online Clearance (OLC), the following equipment is also required:

- Resistor Plug Set for OLC Testing (Fresenius part number 190168).

For machines equipped with the optional blood pressure module, the following equipment is also required to test the module:

- Test Device (Fresenius part number 370090). The Test Device contains two air chambers with calibrated volumes.
- Mercury manometer or equivalent pressure meter accurate to within 1 mmHg at pressures up to 330 mmHg.

1.2 MEASURING FLUID VOLUMES

Several of the following procedures require measuring fluid volumes using graduated cylinders and laboratory burets. When making these measurements do the following:

- Make certain the container is clean and dry before collecting the fluid to be measured. Two drops of fluid are approximately 0.1 ml; enough to affect the accuracy of critical measurements.

- Ensure that no items such as thermometers or tubing are allowed to come in contact with the fluid in the graduate. Such items will change the calibration of the graduate and affect the accuracy of measurements. Both the total volume indicated and the amount of fluid indicated by each increment on the graduated scale will be incorrect. For example, if a graduate is calibrated in 1 ml increments, a piece of tubing in contact with the fluid will cause each increment to be *less* than 1 ml, depending upon the total volume of the tubing that penetrates into the fluid.

- Surface tension causes the fluid to curve into a meniscus (Fig. 1). Measure the volume at the bottom of the meniscus curve as shown.

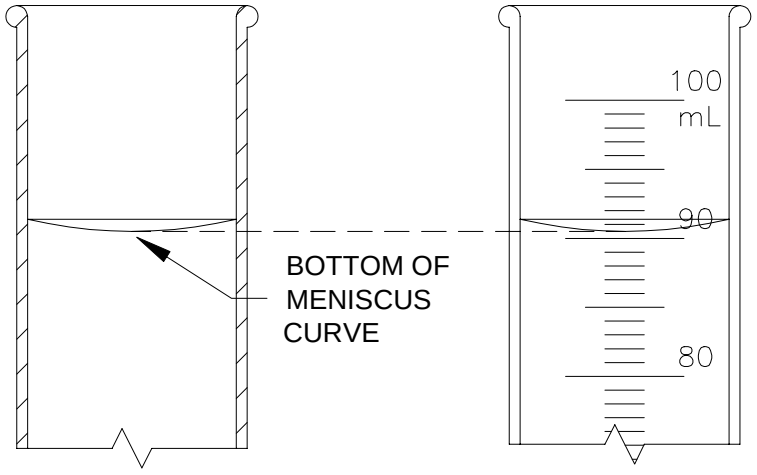


Figure 1. Meniscus Curve.

2.0 QUARTERLY (1000 HOUR) PREVENTIVE MAINTENANCE

Perform the following Preventive Maintenance procedures every 3 months or 1000 hours of machine operation, whichever comes first. Make copies of the Quarterly Preventive Maintenance Checklist provided in the back of this manual and use them to record the maintenance done.

When performing an Annual Preventive Maintenance do not perform the quarterly procedures below first. Go directly to Section 3 and perform the annual procedures described there. You will be referred back to this section to perform the quarterly procedures along with the annual procedures in the most efficient order.

While performing the following procedures, check the floor of the hydraulic unit and all surfaces for moisture that might indicate a leak. Locate and correct any leaks detected. Clean the floor of the hydraulic unit so that future leaks will be readily apparent. Also, check all electrical connectors that can be reached to be sure they are fully seated and there is no strain on the electrical cables.

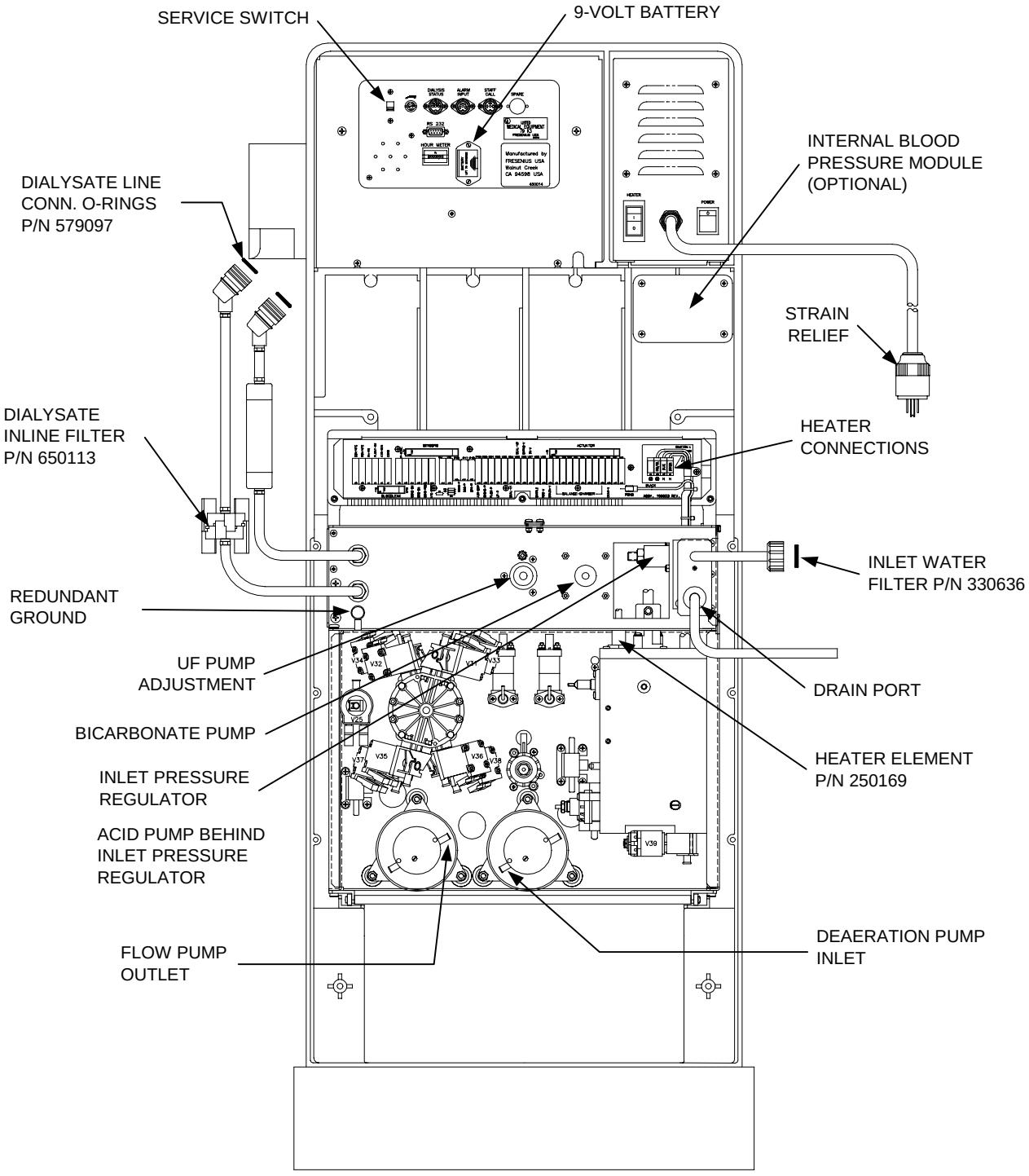


Figure 2. Fresenius 2008H Hemodialysis System, Rear View.

2.1 FILTERS AND O-RINGS

Clean filters and replace O-rings as follows. Replace any filters that appear damaged or corroded.

1. Inlet Water Filter in the inlet connector of the water supply (Fig. 2).

   WARNING
   After cleaning or replacing the inlet filter screen, disinfect the water line inlet as described in the Operator's manual and in accordance with your Unit Policy.

   WARNING
   Do not use excessive O-ring lubricant, as silicone-gel can damage the hydraulic pressure transducers (P-DIAL and CFS).

2. Filters and O-rings in the Concentrate and Bicarbonate Connectors (Fig. 3). Replace all three O-rings in each connector.

3. Dialysate Inline filter (Fig. 2).

4. O-rings in the Dialysate Line Connectors (Fig. 2).

5. Pre-UF Pump Filter. To reach this filter, remove the hydraulic unit. The filter is in the plastic housing in the input line to the UF pump. The inlet line should be the lower line entering the pump. Open the housing to remove the filter screen. If needed, the filter part number is 566307, the same as that used in the Acid and Bicarbonate filters. Replace the Pre-UF Pump Filter if the housing shows signs of leakage or distortion.

2.1A DIASAFE® FILTER (IF APPLICABLE)

If the machine is equipped with a DIASAFE® filter system, replace the DIASAFE® filter and its quick connector O-rings (P/N 579097) every 90 days (quarterly).

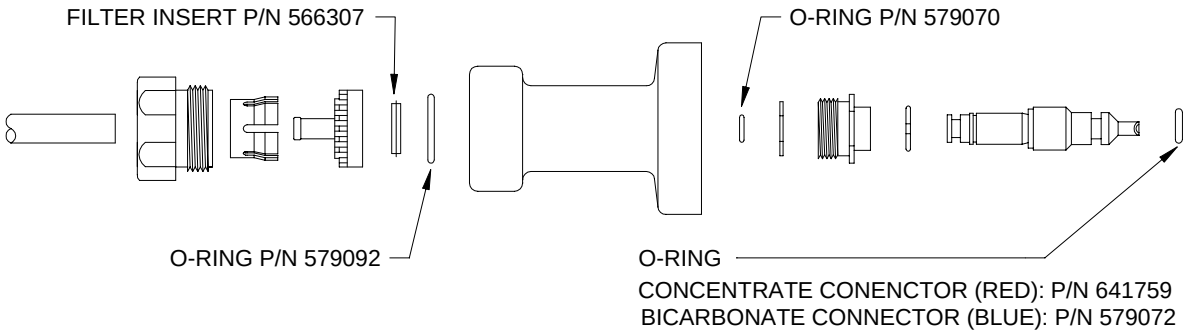


Figure 3. Concentrate and Bicarbonate Connector Assemblies.

2.2 CHECK VALVES

ANNUAL MAINTENANCE

If an Annual maintenance is being performed, replace the following check valves:

1. UF Pump Output. There are two check valves at the UF pump output. One is at the UF pump itself. The other is downstream at the UF Sample Port.

2. Concentrate and Bicarbonate Pump Output (Central Feed Systems only). If the facility has a central feed system, a check valve (part no. 150209) is located at the output of the concentrate pump if the central feed system provides acid, or the bicarbonate pump if the central feed system provides bicarbonate. These valves have a white insert with a 6-pound spring.

CAUTION
Ensure the feed pressure from the central system does not exceed 2 psi.

QUARTERLY MAINTENANCE

If a Quarterly maintenance is being performed, inspect the UF pump check valves (one at the UF pump output and the other downstream at the UF Sample Port). Replace any that show signs of wear or damage. Open each valve and inspect the valve body for cracks, distortion or signs of leakage. Inspect the springs to ensure they are not deformed and are seated properly. Check the poppet for proper O-ring seating. Also, if applicable, inspect the Central Feed System check valves (one at the output of the Concentrate pump and one at the output of the Bicarbonate pump).

CAUTION
If a check valve is replaced, ensure it is oriented correctly to allow fluid flow in the proper direction.

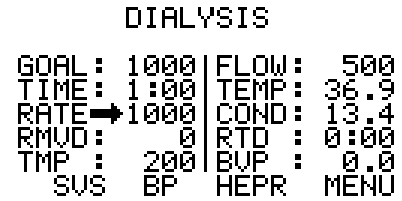
2.3 UF PUMP

Verify the UF pump as follows:

1. Remove the dialyzer connectors from the shunt and place them in a bucket of water on the floor.

2. Place the machine in Dialyze mode and clear all blood alarms. Turn the speed control on the Blood Pump module front panel clockwise so the pump is running (Fig. 7 in Sec 3.16).

3. On the Dialysis screen on the front panel display, set the RATE at 1000.



4. Connect the FLUID SAMPLE/ULTRAFILTRATE output tubing to a 25 ml buret. Open the buret stopcock (Fig 4).

5. Press the UF ON/OFF touchpad. The green light above the touchpad should light, indicating that the UF pump is running and fluid should be pumped into the buret. If this light is flashing, there is a blood alarm or the machine is in a Fill Program and the UF Pump will not run. Correct any conditions as required so the green light does not flash.

> **NOTE**
> If the UF Pump does not provide output even though the green light is on and not flashing, inspect the check valves. If a check valve is installed backwards, the pump will not work.

6. Slide the hydraulic chassis out a few inches so that the UF pump is visible. While the UF pump is stroking, observe the piston and the solenoid. Look for signs of the piston sticking, or evidence of corrosion in the solenoid barrel.

> **NOTE**
> The solenoid is a sealed unit - no lubrication is necessary. Corroded components should be replaced as necessary.

7. When fluid appears in the buret, press the UF ON/OFF touchpad to stop the pump, then adjust the amount of fluid in the buret so the meniscus is on the 25 ml mark (Fig. 4).

8. Press the UF ON/OFF touchpad and allow exactly 24 pulses of fluid into the buret, then press the UF ON/OFF touchpad again to stop the pump.

9. Measure the amount of fluid collected. The level in the buret should be between 0.90 and 1.10 ml on the buret scale indicating that between 23.90 and 24.10 ml was collected. If the volume collected is not within this range, repeat this test to ensure it is done accurately before considering re-calibration or other repairs.

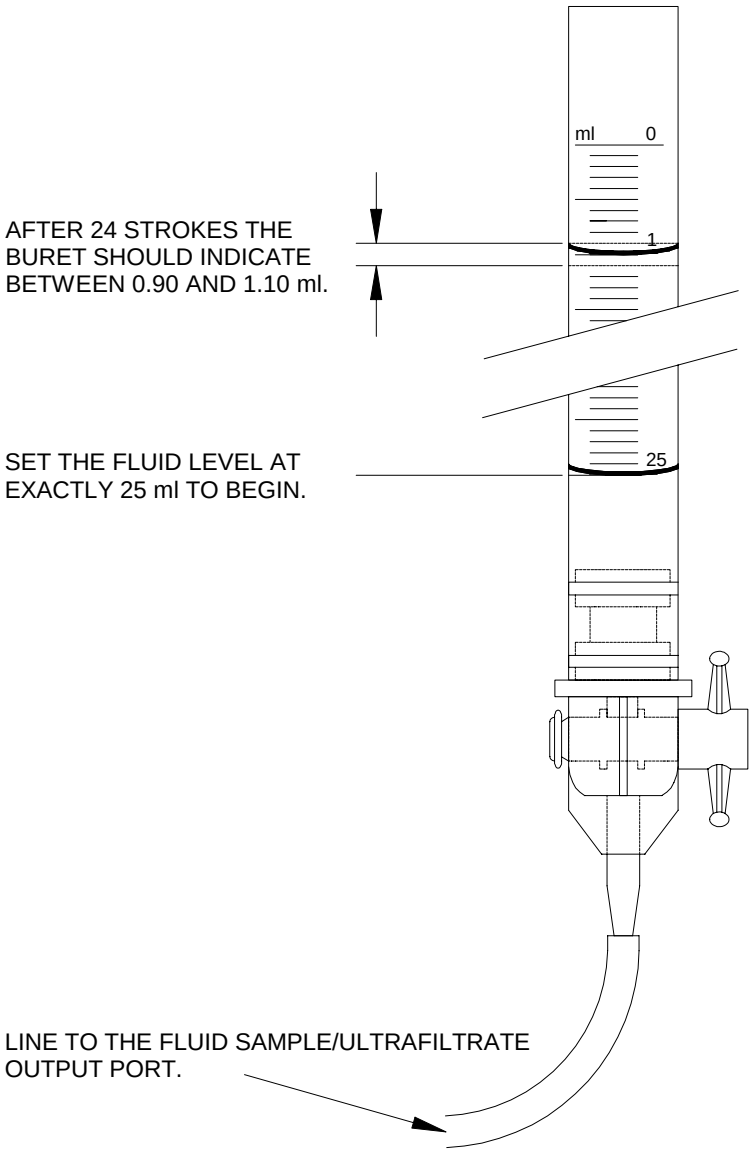


Figure 4. UF Pump Volume Measurement.

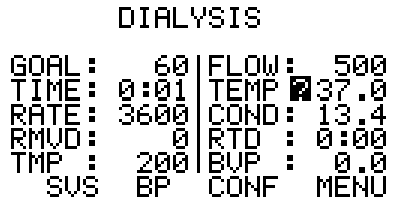
2.4 TEMPERATURE

Verify that the actual dialysate temperature measured by an external meter agrees with the front panel display screen within 0.5°C at 37°C and 39°C as follows:

1. Connect the dialysate lines to an external meter.

2. Place the machine in Dialyze mode with concentrate in the system. Clear any alarms.

3. Select TEMP on the front panel display screen, and press the SET touchpad. The cursor will change to a ?. Press the Up or Down arrow touchpads to select exactly 37.0 as shown:



4. Press SET again. The TEMP line on the display now reads the actual temperature of the dialysate. Wait until this value stabilizes. It will settle very close to the value set, depending upon inlet water temperature and other conditions.

5. After the temperature of the dialysate stabilizes, compare the temperature shown on the front panel display screen TEMP line with the temperature shown on the external meter connected to the dialysate lines. The two readings must be within 0.5° of each other.

6. Repeat steps 3, 4 and 5 with the temperature set to 39.0°C. Verify that the actual temperature reported on the front panel display screen and the external meter are within 0.5° of each other after the temperatures stabilize again.

2.5 CONDUCTIVITY

Verify that the dialysate conductivity measured by the internal cell in the machine agrees with an external meter within 0.1 mS/cm as follows:

1. Connect an external conductivity meter to the dialysate lines.
2. With the machine in Dialysis mode and flow On, compare the value shown on the external meter with the conductivity shown on the Display screen. They must be within 0.1 mS/cm of each other.

2.6 ALARM AND PRESSURE HOLDING TESTS

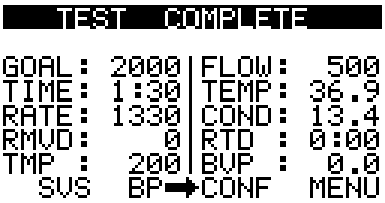
Verify the automatic alarms produce the responses shown in Table 1 and the machine passes the automatic pressure holding test as follows:

1. Place the dialysate lines in the shunt and close the door.
2. Place a venous chamber filled with water in the holder on the level detector module.
3. Place the machine in Dialyze mode and start the blood pump. Clear all blood and water alarms.
4. Press the front panel TEST keypad. The yellow light above the touchpad should light indicating that the alarm test has begun.
5. Observe the machine stepping through the following alarm tests and ensure that each alarm produces all of the responses shown in Table 1.

Table 1. Alarm Tests.

ALARM TEST	RESPONSE
Air Detector	1. Red visual alarm 2. Venous clamp closes 3. Blood pump stops
Blood Leak	1 Red visual alarm 2. Venous clamp closes 3. Blood pump stops
Arterial Pressure	1. Red visual alarm 2. Venous clamp closes 3. Blood pump stops
Venous Pressure	1. Red visual alarm 2. Venous clamp closes 3. Blood pump stops
TMP	1. Red visual alarm 2. Venous clamp closes 3. Blood pump stops
9-Volt Battery	Passes if battery voltage is greater than 7.0 volts under a load of 22Ω.
Optical Detector	1. Lower venous alarm limit rises to 0 mmHg causing a venous pressure alarm 2. Venous clamp closes 3. Blood pump stops
Temperature	1. Red visual alarm 2. Yellow visual bypass 3. Machine in Bypass mode (no flow through the dialysate flow indicator).
Conductivity	1. Red visual alarm 2. Yellow visual bypass 3. Machine in Bypass mode (no flow through the dialysate flow indicator).

6. When the tests shown in Table 1 are complete, the machine conducts a pressure holding test. Various pressure values will be shown on the front panel display screen. When the test ends verify that the display screen reports TEST COMPLETE as follows, indicating that all the tests were passed successfully. Press the RESET keypad.



7. Test the UF pump integrity as follows:

   - Pull the hydraulic out and remove the output tube from the UF pump.

   - Install a 24" tube (P/N 545325) to the empty output port. Route this tubing out the back of the machine so that it will not be kinked or pinched when the hydraulics is closed. Close the hydraulics and place the other end of tube into a collection container.

   - Conduct steps 1-6 again.

     - If the pressure holding test fails, refer to Section 4.1.

     - If the pressure holding test passes, disconnect the 24" tube and reconnect the original output tube to the UF pump.

8. Test the audible alarm as follows:

   - Place a piece of opaque paper inside the housing of the optical detector to simulate a line containing blood. Close the door of the optical detector.

   - Open the shunt door. Verify that the machine responds with an audible alarm. Press the MUTE touchpad and verify that the MUTE lamp on the front panel lights, and the audible tone stops.

2.7 LABELS AND MECHANICAL CONDITION

Before returning the machine to clinical use after successful completion of all of the Preventive Maintenance procedures listed above, complete the following:

- Verify that the machine label with serial number is in place, usually on the back of the cabinet near the Monitor Control Unit. Record this serial number on the Preventive Maintenance Checklist form.

- Verify that no dialysate spills or leaks are visible in the hydraulics or on the bottom of the cabinet. Clean and dry any spills found and correct the source.

- Verify that all covers are replaced and that all cover screws and mounting hardware has been replaced.

CAUTION
Reliable operation of the machine requires that all screws and covers be properly installed. Ensure that all screws and covers are in place before returning the machine to clinical use.

- Clean the exterior surfaces of the machine and remove all traces of dirt, oil or other contaminants.

CAUTION
Do not use a cleaner containing Dimethyl Benzylamonium Chloride. This ingredient will damage many plastic surfaces. Certain brands of cleaners specifically marketed to clinics and hospitals contain this ingredient. Check the contents of any unknown cleaner before using it.

3.0 ANNUAL (4000 HOUR) PREVENTIVE MAINTENANCE

Perform the following Preventive Maintenance procedures every 12 months or 4000 hours of machine operation, whichever comes first. Perform the procedures in the order given below to complete the Annual Preventive Maintenance and the Quarterly Preventive Maintenance. The following procedures will refer back to the Quarterly Preventive Maintenance procedures at the proper times for you to work in the most efficient manner.

Make copies of the Annual Preventive Maintenance Checklist provided at the back of this manual and use them to record the maintenance done.

3.1 FILTERS, O-RINGS AND CHECK VALVES

Perform the Quarterly Preventive Maintenance procedures in Sections 2.1 and 2.2.

3.2 DIAPHRAGM PUMPS

Rebuild the UF, Bicarbonate and Concentrate diaphragm pumps as described in Section 4.

3.3 HEATER ELEMENT

Remove the heater element from the hydroblock on the machine (Fig. 2). Inspect the heater element for signs of corrosion. If corrosion exists, replace the heater element.

WARNING

Dangerous high voltage is present at these connections when the machine is operating. The heater element is hot enough to inflict serious injury if it is touched while power is applied or shortly after power is removed. Ensure the machine is disconnected from the wall outlet.

3.4 HIGH VOLTAGE AC CONNECTIONS

WARNING
Dangerous high voltage is present at the connections accessed in this procedure when the machine is operating. Ensure the machine's power plug is disconnected from the wall outlet before proceeding.

1. Remove power from the machine then check and tighten the 8-pin heater connections next to the distribution board (Fig. 2).

2. Inspect the power plug for loose or frayed wires. Ensure the strain relief is securely fastened.

3. With a digital multimeter, measure the resistance between the round (ground) pin on the power plug and the redundant ground terminal on the machine (Fig. 2). Verify that the resistance is less than 0.2 ohm. If the value is above 0.2 ohm, measure the internal resistance of your meter by shorting the leads together, then subtract this value from the resistance measured between the power plug ground pin and the redundant ground terminal on the machine to obtain the true ground resistance.

WARNING
Do not operate the machine if the resistance is greater than 0.2 ohm. A shock hazard to operators and patients could exist.

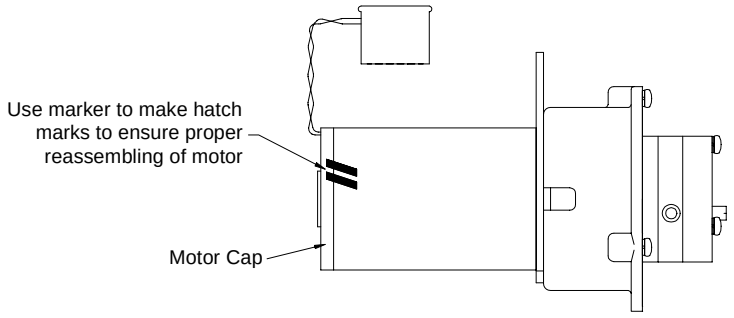
4. Perform the electrical safety checks required by local codes, facility procedure and the Joint Commission on Accreditation of Healthcare Organizations.

3.5 DEAERATION MOTOR BRUSHES

Replace the deaeration motor brushes every 8000hrs using the following steps:

1. Remove the complete deaeration motor/pump assembly from the machine.

2. Using a marker, make hatch marks on the motor housing and motor cap as illustrated below. These marks will ensure the correct alignment when reassembling the motor case.



3. Using a T-20 Torx screwdriver, remove the two screws holder the motor cap to the motor housing.

4. Remove the motor cap to gain access to the motor brushes. Replace the motor brushes.

5. Reassemble the motor, aligning the hatch marks.

6. While holding the pieces together, install and tighten the two T-20 screws.

NOTE
If the motor case and motor cap are not installed using the hatch marks, the motor will run in reverse and flow errors will result.

3.6 INLET WATER PRESSURE REGULATOR

Verify that the regulator provides the proper water pressure as follows:

1. Turn off the dialysate flow.
2. Shut off the water supply to the machine.
3. Install a gauge with a T-fitting to monitor the pressure at the outlet side of the Inlet Pressure Regulator (Fig 2).

> **CAUTION**
> Use tie wraps or tubing clamps to secure the connections. The water pressure may be sufficient to blow the lines off the fittings if they are not secured.

4. Turn the water supply to the machine On.
5. With the dialysate lines in the shunt, select Dialysis mode and start the dialysate flow. The pressure gauge will cycle between two readings as water inlet valve opens and closes.
6. Verify that the pressure gauge reads between 18 and 20 psi when the pressure is at its highest value, and reads greater than 8 psi when the pressure is at its lowest value.

> **NOTE**
> Readings below 8 psi at the lowest level indicates inadequate inlet water flow into the machine. This may be caused by a dirty inlet filter screen or problems with the treated water supply.

7. Turn the machine Off, turn off the source water supply, remove the gauge and reconnect the tubing using clamps to prevent leaks.
8. Turn the treated water supply source On, turn the machine On and select Dialysis mode. Start dialysate flow and inspect all hoses and connections. Ensure that there are no leaks.

3.7 ONLINE CLEARANCE TEST (IF APPLICABLE)

If the machine is equipped with Online Clearance (OLC), conduct the following test:

1. Turn the machine ON and allow the machine to run in dialysis mode at 500ml/min flow rate with the dialysate lines in the shunt.

2. The machine will automatically start the "OLC Self Test" by displaying a banner. When the test starts, open the shunt door. This will cancel the test.

> **NOTE**
> The cancel message will be hidden by the "Shunt Door Open" banner

3. Close the shunt door and verify that the "OLC Self Test" banner is gone.

4. Once the "OLC Self Test" has been canceled, allow the machine to run in dialysis mode for approximately 10 minutes. This allows the machine to come up to temperature and conductivity.

> **NOTE**
> If the installed software version is 9.68 or greater, the “OLC Self Test” will not automatically start. In this case, allow the machine to run in dialysis mode for approximately 10 minutes to come up to temperature and conductivity.

5. Once the machine is up to temperature and conductivity, switch to the debug screens by pressing and holding the [↑] and [↓] keys at the same time for approximately 1 sec. The main display will change indicating that the machine is in debug mode.

6. Use the [↑] and [↓] keys to go to debug screen #23.

7. On debug screen #23, locate CPRE and CPOS and observe them for 1 minute. During this time, record the most stable value observed for each in the table below.

CPRE	CPOS	Difference
	-	=

8. Calculate the difference between CPRE and CPOS values and record it in the table above.

9. Verify that the difference between CPRE and CPOS is less than 500. If the difference is greater than or equal to 500, recalibrate both PRE and POST Conductivity cells and retest.

10. If the difference between CPRE and CPOS is less than 500, remove x3 (MON-NTC) and x7 (COND) from the distribution board.

11. Using the Resistor Plug Set for OLC Testing (P/N 190168), plug the 6.04KΩ plug into x3 (MON-NTC) and the 274Ω plug into x7 (COND) on the distribution board.

> **NOTE**
> Due to the resistor placement inside the OLC test plugs, the orientation of the plug when inserted onto the distribution board is irrelevant.

12. On debug screen #23, locate TPRE and observe its value for 1 minute. During this time, record the highest and lowest values observed in the table below.

	Highest Value	Lowest Value	Difference
TPRE		-	=

13. Calculate the difference between the highest and lowest TPRE value and record it in the table above.

14. Verify that the difference for TPRE < 2. If the difference for TPRE > 2, then possible causes are sensor board, motor noise, or -12V problems.

15. Again on debug screen #23, locate CPRE and observe its value for 1 minute. During this time record the highest and lowest values observed in the table below.

	Highest Value	Lowest Value	Difference
CPRE	-		=

16. Calculate the difference between the highest and lowest CPRE value and record it in the table above.

17. Verify that the difference for CPRE < 8. If the difference for CPRE > 8, then possible causes are sensor board, motor noise, or -12V problems.

18. Remove the 6.04KΩ and 274Ω plug from the distribution board and reconnect the original connectors.

19. Remove x44 (NTC-POST) and x13 (COND-POS) from the distribution board.

20. Using the Resistor Plug Set for OLC Testing (P/N 190168), plug the 6.04KΩ plug into x44 (NTC-POST) and the 274Ω plug into x13 (COND-POS) on the distribution board.

21. On debug screen #23, locate TPOS and observe its value for 1 minute. During this time record the highest and lowest values observed in the table below.

	Highest Value	Lowest Value	Difference
TPOS	-		=

22. Calculate the difference between the highest and lowest TPOS value and record it in the table above.

23. Verify that the difference for TPOS < 2. If the difference for TPOS > 2, then possible causes are sensor board, motor noise, or -12V problems.

24. Again on debug screen #23, locate CPOS and observe its value for 1 minute. During this time record the highest and lowest values observed in the table below.

	Highest Value	Lowest Value	Difference
CPOS	-	=	

25. Calculate the difference between the highest and lowest CPOS value and record it in the table above.

26. Verify that the difference for CPOS < 8. If the difference for CPOS > 8, then possible causes are sensor board, motor noise, or -12V problems.

27. With the 6.04KΩ plug on x44 (NTC-POST) and the 274Ω plug on x13 (COND-POS) of the distribution board, verify that CPOS does not change more then 10 increments when the dialysate flow is turned OFF. (Note: Conduct this test for the dialysate flow ON to OFF transition.)

28. Remove the 6.04KΩ and 274Ω plug from the distribution board and reconnect the original connectors.

29. Once the distribution board connections are back in place, turn the machine OFF.

3.8 DEAERATION AND LOADING PRESSURE

Verify that the deaeration pressure is between –24 and -25 inHg and the loading pressure is between 18 and 20 psi (between 23 and 25 psi if a DIASAFE® filter system is installed) as follows:

1. With dialysate flow Off, install a gauge with a T-fitting to monitor the pressure on the inlet (suction) side of the deaeration pump (Fig 2).

2. Connect a gauge equipped with a yellow connector into the red ACID/ACETATE RINSE port.

3. In Dialysis mode, turn dialysate flow On and verify that the gauge on the deaeration pump indicates between -24 and -25 inHg. The needle will be vibrating somewhat. Verify that it does not go higher than -24 inHg or lower than -25 Hg. Verify that the gauge in the RINSE port indicates between 18 and 20 psi (between 23 and 25 psi if a DIASAFE® filter system is installed).

3.9 FLOW RELIEF PRESSURE

Verify that the flow relief pressure is between 29 and 30 psi (between 35 and 36 psi if a DIASAFE® filter system is installed) as follows:

1. With dialysate flow Off, install a gauge with a T-fitting to monitor the pressure on the output side of the flow pump (Fig. 2).

2. Turn On the dialysate flow and set the flow to 800. Clamp the output tubing of the flow pump after the gauge. Verify the gauge indicates between 29 and 30 psi (between 35 and 36 psi if a DIASAFE® filter system is installed).

3.10 TEMPERATURE

Verify that the dialysate temperature shown on the front panel Display screen agrees with an external meter within 0.5°C at 37°C and 39°C as described in Section 2.4.

3.11 CONDUCTIVITY

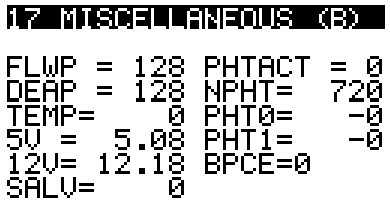
Verify that the dialysate conductivity measured by the internal cell in the machine agrees with an external meter within 0.1 mS/cm as described in Section 2.5.

3.12 VOLT HI LO DETECT

Verify that the 5-volt supply is operating within 0.2 volts as reported on the Debug screen as follows:

1. Enter Debug mode by pressing the front panel Up and Down arrow touchpads simultaneously.

2. Press the Up or Down arrow touchpads to select the following screen:



3. Note the 5V= value on the display screen. This value must be between 4.8V and 5.2V.

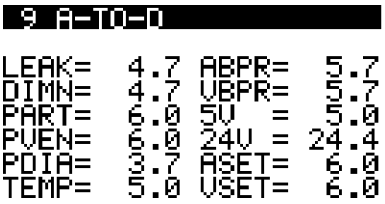
NOTE
If the 5V= value is not within limits, the problem is most likely the 12 volt supply out tolerance. Perform the Volt Hi Lo Detect calibration procedure.

3.13 BLOOD LEAK AND DIMNESS

Verify that the Blood Leak level is between 4.5 and 5.2 volts and the Blood Dimness level is within 5.0±1.0 volts as follows:

1. Enter Debug mode by pressing the front panel Up and Down arrow touchpads simultaneously.

2. Press the Up or Down arrow touchpads to select the following screen:



3. Note the LEAK= value on the display screen. This value must be between 4.5 and 5.2.

4. Note the DIMN= value on the display screen. This value must be between 4.0 and 6.0.

NOTE

If these values are outside the limits given, perform a bleach rinse to clean the glass detector tube inside the machine before considering other repairs.

3.14 ARTERIAL, VENOUS AND TRANS-MEMBRANE PRESSURE

ARTERIAL PRESSURE

1. Inspect the internal pressure transducer protector for contamination. If contamination is found, replace the pressure transducer protector (P/N 650158) and remove and disinfect the pressure port with 1:100 bleach for a minimum of 15 minutes.
2. Turn the Blood Pump SPEED control (Fig. 7 in Sec 3.16) fully counter-clockwise to turn the Blood Pump Off.
3. Open the arterial transducer port **P** ART on the blood pump module to air (atmospheric pressure). Verify that the PRESSURE ARTERIAL led display indicates 0.
4. Attach a syringe and a calibrated pressure gauge to the **P** ART port using a T-fitting.
5. Push the syringe in to show a pressure of 200 mmHg on the external gauge. Verify that the PRESSURE ARTERIAL led display indicates 200.
6. Increase the pressure to a range of 310 - 315mmHg. Clamp off the tubing at the syringe and monitor for 30 seconds. The maximum allowable leakage is 2mmHg in 30 seconds.

VENOUS PRESSURE

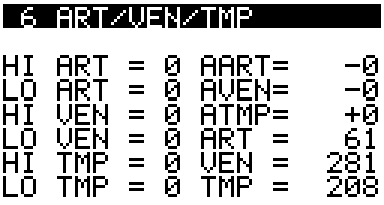
1. Inspect the internal pressure transducer protector for contamination. If contamination is found, replace the pressure transducer protector (P/N 650158) and remove and disinfect the pressure port with 1:100 bleach for a minimum of 15 minutes.
2. Open the venous transducer port **P** VEN on the level detector module to air (atmospheric pressure). Verify that the PRESSURE VENOUS led display indicates 0.
3. Attach a syringe and a calibrated pressure gauge to the **P** VEN port using a T-fitting.
4. Push the syringe plunger in to show 400 mmHg on the external pressure gauge. Verify that the PRESSURE VENOUS led display indicates 400.
5. Decrease the pressure to a range of 310 - 315mmHg. Clamp off the tubing at the syringe and monitor for 30 seconds. The maximum allowable leakage is 2mmHg in 30 seconds.

TRANS-MEMBRANE PRESSURE

1. With dialysate flow On, ensure the dialysate lines are full of fluid and no air is visible passing through the flow indicator.
2. Hang a four-way connector to the I.V. pole at normal dialyzer height.
3. Set dialysate flow to 500 ml/min, then press SET on the front panel.
4. Turn dialysate flow Off, remove the dialysate lines from the shunt and attach them to the connector.

> **NOTE**
> Filling the lines before removing them from the shunt will avoid wetting the pressure gauge transducer during the test.

5. Connect a 30cc syringe to one of the four-way connector outlets and a pressure gauge to the remaining outlet.
6. Enter Debug mode by pressing the front panel Up and Down arrow touchpads simultaneously.
7. Press the Up or Down arrow touchpads to select the following screen:



8. Use the syringe to set the pressure on the external gauge to 0 mmHg. Calculate the dialysate pressure measured by the machine as follows:
   - Note the value shown for TMP= on the display screen.
   - Subtract the value shown for VEN= on the display screen.
9. Verify that the calculated value is between +20 and -10 mmHg.
10. Use the syringe to create a pressure of -250 mmHg on the pressure gauge.
11. Calculate the dialysate pressure measured by the machine again as described in step 8. Verify that the calculated value is between -230 and -260 mmHg.

3.15 DIALYSATE FLOW

Verify the dialysate flow is within ±3% of the stated rate at 500 ml/minute as follows:

NOTE
Flow rates at 300 and 800 ml/minute are controlled by the software. Testing the rate at 500 ml/minute verifies the accuracy of all three rates.

1. In Dialysis mode, turn the dialysate flow On at 500 ml/minute. Verify that the UF pump is Off. Allow the dialysate flow to run for 2 minutes, minimum, before continuing.

2. Collect spent dialysate from the drain port on the back of the machine (Fig. 2) for exactly 1 minute. Verify that the amount collected is between 485 and 515 ml.

3.16A HEPARIN PUMP

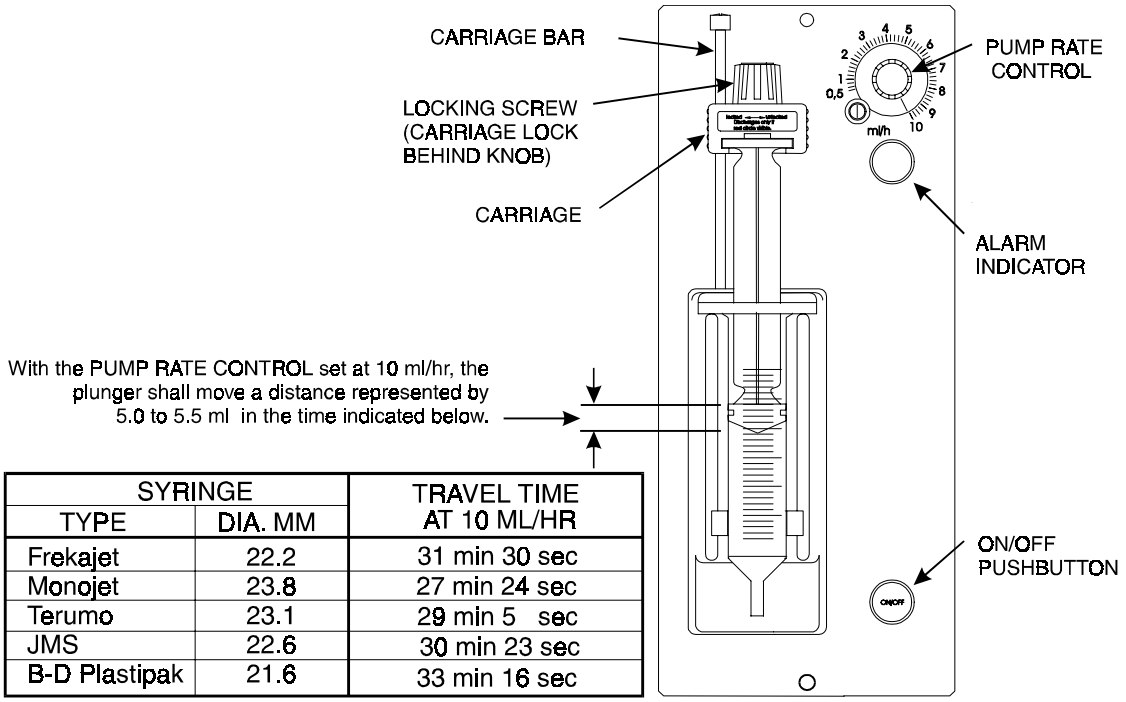
If the machine is equipped with a heparin pump, clean and test the pump as follows:

1. Press the Heparin Pump carriage lock (see Fig 5). Verify that the carriage moves freely up and down.

2. Clean the carriage bar.

3. Choose the type of syringe most commonly used in your unit from the list in Fig. 5 and install the syringe in the pump.

4. Adjust the carriage manually to set the plunger on the 25 ml scale mark on the syringe. Note the reference point on the plunger that is aligned on the mark.



SYRINGE		TRAVEL TIME AT 10 ML/HR
TYPE	DIA. MM	
Frekajet	22.2	31 min 30 sec
Monojet	23.8	27 min 24 sec
Terumo	23.1	29 min 5 sec
JMS	22.6	30 min 23 sec
B-D Plastipak	21.6	33 min 16 sec

Figure 5. Heparin Pump Module Rate Measurement

5. Set the Heparin Pump rate control for a delivery rate of 10 ml/hour.

> **NOTE**
> The rate potentiometer should be replaced every 3 to 4 years. See procedure P/N 507105 for calibration of the rate potentiometer circuit. If the potentiometer has not been changed before, and the module is more than 3 to 4 years old, replace the potentiometer now.

6. Press the ON/OFF pushbutton on the Heparin Pump to start the pump and start timing the interval with the stopwatch. Verify that the ON/OFF pushbutton on the Heparin Pump lights.

7. Allow the pump to run exactly the length of time shown on Fig. 5 for the type of syringe you are using, then press the ON/OFF pushbutton on the Heparin Pump to stop the pump.

8. Verify that the reference point on the syringe plunger chosen in step 4 has moved to between 19.5 and 20.0 ml on the syringe scale.

9. Move the Heparin Pump carriage all the way to the bottom of its travel.

10. Press the ON/OFF pushbutton on the Heparin Pump to start the pump.

11. Verify that the red alarm indicator on the Heparin Pump module lights and an alarm occurs within approximately 5 minutes.

3.16B DIGITAL HEPARIN PUMP MODULE

If the machine is equipped with the Computerized Heparin Pump Module, clean and test the pump as follows:

1. Press the Heparin Pump carriage lock button (see Fig. 6). Verify that the slide carriage moves freely up and down.

2. Clean the carriage bar.

3. Use a Luer lock 10cc BD syringe, only. Install the syringe into the pump.

4. Adjust the carriage manually to set the plunger on the 10 ml scale mark on the syringe. Note the reference point on the plunger that is aligned on the mark.

5. Clear AMOUNT and set BOLAMT to 5.0.

6. Move the arrow to BOLUS. Press SET to start the pump and start timing the interval with the stopwatch.

7. When the pump stops, verify that the time to run a 5ml Bolus was between 29 and 30 seconds.

8. Also, verify that the screen AMOUNT reads 5.0 and that the reference point on the syringe plunger has moved to between 4.8 to 5.2 on the syringe scale.

9. Move the Heparin Pump carriage all the way to the end of its travel.

10. Set RATE to 9.9. Move the arrow to OFF and press SET. This toggles OFF to ON.

11. Verify that a “HEPARIN PUMP ALARM” is displayed on the status line within 2 minutes. Note: If the machine is not alarm free, another message of higher priority may be displayed on the status line.

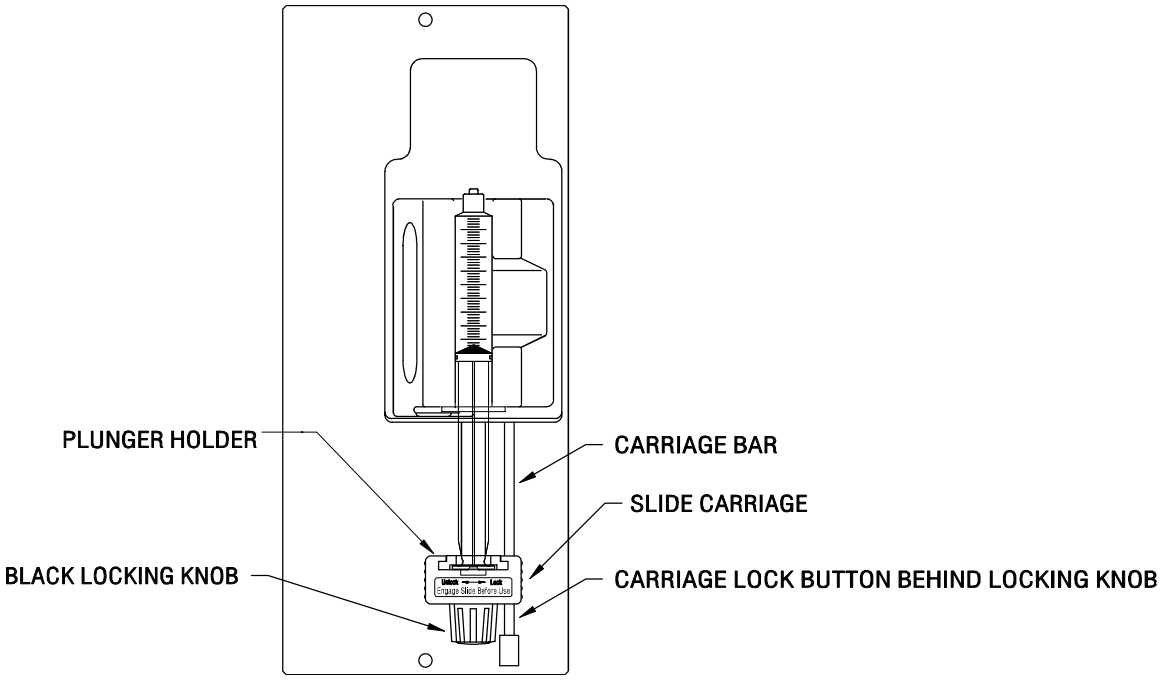


Figure 6. Heparin Pump Module Rate Measurement

3.17 BLOOD PUMP

Clean and test the arterial blood pump module and, if equipped, the single-needle blood pump module as follows (Fig. 7):

1. Remove the blood pump rotor by opening the door, pulling out the handle and turning the rotor 90 degrees
2. Clean the rollers with a cloth dampened only with water.
3. Clean the inside of the blood pump housing with the damp cloth. Compressed air may be used if it is available.
4. Remove the blood pump module from the machine and inspect the motor gearbox. In heavy use, some oil may accumulate on the gearbox housing. Wipe the housing clean.
5. Reassemble the blood pump module replace it in the machine.
6. Place the machine in Dialyze mode and clear all blood alarms.
7. Turn the blood pump module rate control clockwise to start the pump.

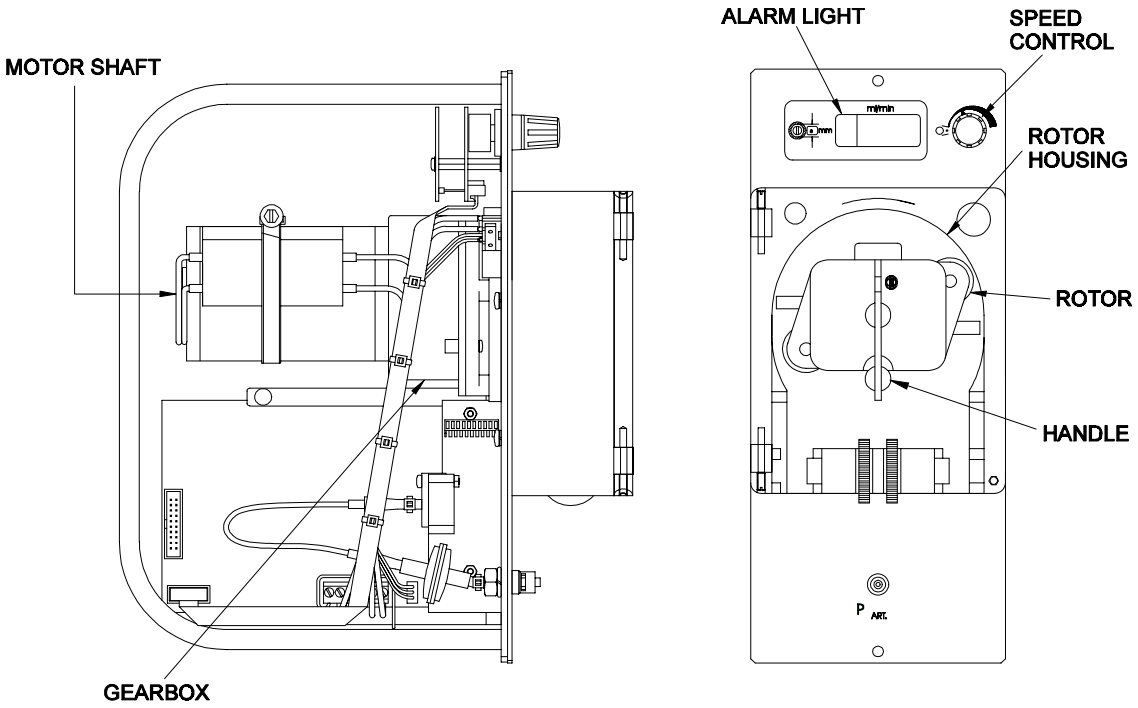


Figure 7. Blood Pump Module.

8. Open the blood pump door. Verify that the red alarm light on the blood pump module lights within 15 or 30 seconds.

NOTE

Delay time before the blood pump alarm lights is set by J175 on circuit board LP340 inside the blood pump.

9. Close the blood pump door and press RESET on the monitor unit front panel to clear the alarm.

10. Test the pump as follows:

- Set the Tubing Size Selector to 8mm.

NOTE
Use the 8mm setting regardless of the size blood line normally used. Do not install a bloodline in the pump.

- Set the front panel pump speed control to minimum (fully counter-clockwise). Verify that the speed display indicates:

000

- Set the speed control so the display indicates:

450

- Use a stopwatch or a tachometer to measure the pump rotation rate. Verify that the motor shaft speed is between 1873 and 1933 rpm or the time required for the pump head to make exactly 10 revolutions is between 14.41 and 14.91 seconds.

NOTE
Most mechanical tachometers are not capable of measuring the motor speed to the accuracy required. If you use a tachometer, be certain it is capable of actually measuring the shaft speed within the tolerance shown.

- Insert a bloodline in the pump. Do not change the setting of the tubing size selector, even if you are not using 8mm tubing.

- Restart the pump and verify that the motor shaft speed is still between 1873 and 1933 rpm or the time required for the pump head to make exactly 10 revolutions is between 14.41 and 14.91 seconds.

- Connect a pressure gauge to the bloodline in the pump (Fig. 8) and allow the rotor to pull up 37°C ± 1.5°C water. Let this fluid flow past the pressure gauge long enough to clear out air.

- With the pump running at 600ml/min, clamp the outlet so that the pressure gauge is between the output of the pump and the clamp (Fig. 8). The peak pressure on the gauge must be between 25 and 35 psi. If the peak pressure is out of range, replace the blood pump rotor springs (part no. 650174).

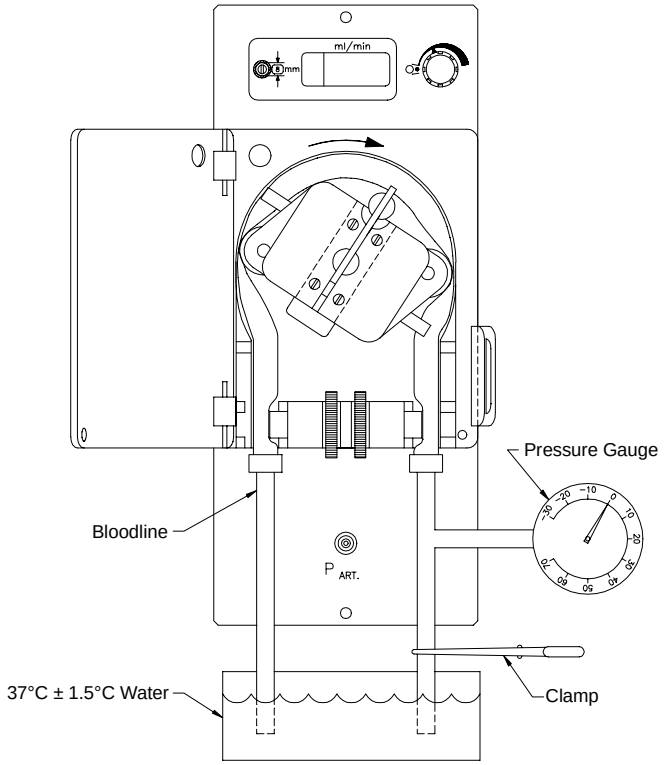


Figure 8. Blood Pump Rotor Occlusion Test.

- Set the Tubing Size Selector to agree with the size of bloodline used in the pump.

3.18 LEVEL DETECTOR

Inspect the Level Detector Module for an external return spring on the venous clamp (Fig. 9). If present, replace the spring (part no. 563001). Test the clamp as follows:

1. Place a venous line in the occlusion clamp. Do not connect this line to the venous chamber in the level detector.

2. Place the lower end of the venous line below the occlusion clamp in a container of water positioned so that air escaping from the end of the line is easily seen.

3. Connect a syringe and a pressure gauge to the venous line above the occlusion clamp.

4. Position the Level Detector so you can watch the Channel 1 and Channel 2 LED's on the circuit board (Fig. 9).

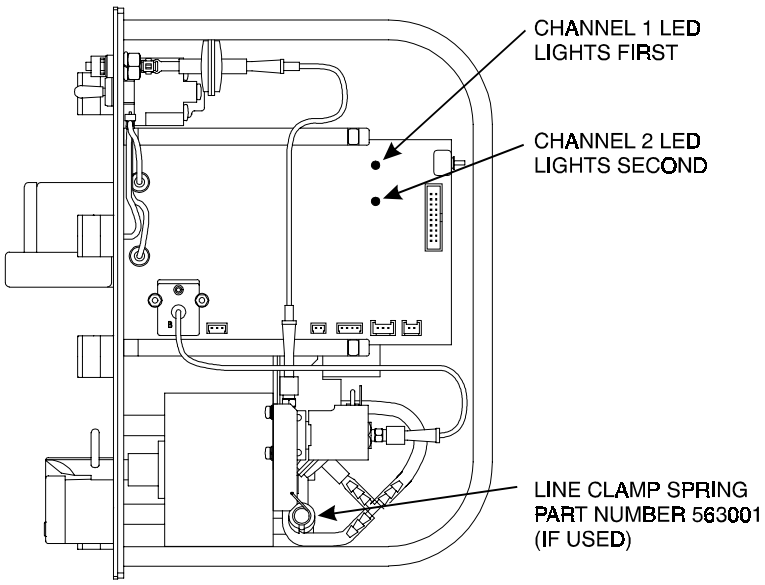


Figure 9. Level Detector Module.

5. Place the machine in Dialysis mode and turn the blood pump On. Clear all alarms.

6. Calibrate level detector (Refer to Section 3.2 of the 2008H Calibration Procedures – Fresenius part number 500604)

7. While watching the Channel 1 and Channel 2 LED's, remove the venous chamber to create a blood alarm and close the venous clamp. Verify that the Channel 1 LED lights first followed quickly by Channel 2.

8. With the syringe, apply a pressure of between at least 30 psi (1550 mmHg) to the venous line while watching the end of the venous line in the water.

9. Verify that no air escapes from the venous line, indicating that the clamp is fully occluding the line.

3.19 ALARM AND PRESSURE HOLDING TESTS

Perform the Quarterly Preventive Maintenance procedures in Section 2.6.

3.20 RINSE CHECKS

Perform the Rinse Checks as follows:

1. Place the machine in Rinse mode, then turn the water supply off. Verify that the display screen shows NO WATER.

2. Start rinse mode, and watch the flow from the drain line. The water from the drain line will stop at one point for 15 seconds. At this time put the drain line in a 1000ml graduated cylinder. Start timing when the flow starts again. At 30 seconds, remove the line from the graduated cylinder. Verify that a minimum of 310ml is collected.

3. Connect the dialysate lines to an external meter capable of reading at least 85°C.

4. Select Heat Disinfect mode on the display screen. The machine normally will not run in Heat Disinfect mode with the dialysate lines off the shunt. Start the machine in Heat Disinfect mode with the dialysate lines on the external meter as follows:

    - Leave the shunt door open.

    - Reach up into the opening at the bottom of the shunt and find the two spring-loaded switches that normally protrude through the holes next to the connectors when the door is closed. Push these switches in with your fingers, simulating dialysate lines connected to the shunt.

    - While holding these switches pushed in, press SET on the front panel to start the Heat Disinfect mode, then let go of the switches inside the shunt. Leave the shunt door open; closing it will stop the Heat Disinfect mode.

    WARNING
    Scalding hot water is passing through the dialysate lines and the external meter manifold. Allow the dialysate lines and the external meter manifold to cool before disconnecting the lines.

5. The Heat Disinfect timer will not be operating. It is not needed. Monitor the external temperature meter and verify that the temperature rises to between 80°C and 90°C.

3.21 BATTERY AND POWER FAILURE ALARM

Replace the 9-volt battery located behind the Monitor Unit (Fig. 2). The battery is inside the plastic housing. Press the cover in and to the left to release it, then pull it out.

After replacing the battery, test the Power Failure alarm by removing the machine power plug from the wall outlet. Verify that the audible alarm sounds.

3.22 INTERNAL BLOOD PRESSURE MODULE

If the machine is equipped with an internal blood pressure module (Fig. 2), test it as follows:

1. Connect the pressure tubing from the module to the 700ML port on the Test Device. Ensure the tubing fits snugly on the ports.

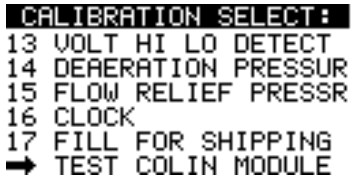
2. Place the machine in Service mode as follows:

   - Press the POWER touchpad to turn the machine Off.

   - On the back of the Monitor Unit, place the red Service switch in the Up position (Fig. 2).

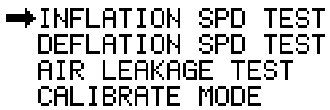
   - Press the POWER touchpad again to turn the machine On. The screen will display:

3. Press the SET touchpad to select CALIBRATION, then press the down arrow touchpad to indicate the Colin Module test:

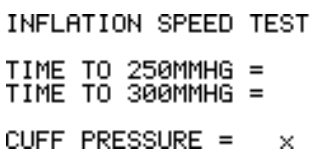


NOTE
The name Colin refers to the manufacturer of the blood pressure module used in the Fresenius 2008H machine.

4. Press the SET touchpad. The screen will display:



5. Press the Up and Down arrows if needed to select INFLATION SPD TEST. Press SET. The blood pressure module will pressurize the Test Device and report the times:



6. Verify that the TIME TO 250MMHG is 2.8 seconds, or greater, and the TIME TO 300MMHG is 7.3 seconds or less. The CUFF PRESSURE value will reach a peak of about 200. The exact value is not important.

7. Move the pressure tubing to the 220ml port on the Test Device.

8. Press SET to return to the blood pressure module test menu. Press the Up and Down arrows as needed to select DEFLATION SPD TEST and press SET.

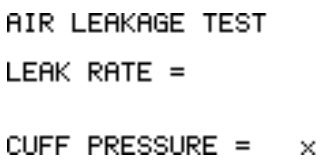
9. The blood pressure module will depressurize (deflate) the Test Device and report the deflation speed at various pressures in mmHg per second. Verify that the values reported are within the following ranges.

PRESSURE	MINIMUM	MAXIMUM
RATE AT 240MMHG	4.6	6.2
RATE AT 160MMHG	4.6	6.2
RATE AT 80MMHG	3.3	5.0
RATE AT 40MMHG	2.6	4.4

10. Move the pressure tubing back to the 700ML port on the Test Device.

11. Press the SET touchpad to return to the blood pressure module test menu. Press the Up and Down arrows as needed to select AIR LEAKAGE RATE and press SET.

12. The blood pressure module will pressurize the Test Device as indicated by a rise in the CUFF PRESSURE displayed to approximately 200. A four-minute internal timer is then activated automatically. Any change in the pressure being held will show on the CUFF PRESSURE line of the display:



13. At the end of four minutes, the pressure is automatically released and the LEAK RATE in mmHg per minute is displayed. Verify that the LEAK RATE does not exceed 3mmHg.

14. Disconnect the pressure tube from the Test Device and connect it to a mercury manometer or similar pressure meter accurate to within 1 mmHg.

15. Press the SET touchpad to return to the blood pressure module test menu. Press the Up and Down arrows as needed to select CALIBRATION MODE and press SET.

16. The blood pressure module will pressurize the line. When the pressure shown on the display screen an on the external meter stabilizes, verify that they agree within 3mmHg.

CAUTION
Do not exceed 330 mmHg in the following step. The blood pressure module may be damaged if this pressure is exceeded.

17. Remove the hose from the external meter and connect it to a large syringe (60 cc) that has its plunger pulled back. Use the syringe to over-pressurize the blood test module while watching the display carefully. Verify that at between 320 and 330 mmHg indicated on the display screen, the pressure is automatically released.

18. Place the machine in normal operating mode again:

    - Press the POWER touchpad to turn the machine Off.
    - Place the red Service switch to the Down position.

3.23 FINAL CHECKS

1. Check the machine for any optional components that are not included here. Perform the preventive maintenance tests provided with those units.

2. Check the labels, mechanical condition and clean the machine as described in Section 2.7.

4.0 REBUILDING THE DIAPHRAGM PUMPS

The machine contains two types diaphragm pumps. The ultrafiltration (UF) pump is a solenoid coil type. The concentrate and bicarbonate pumps are stepper motor types.

4.1 REBUILDING THE ULTRAFILTRATION PUMP

Figure 10 shows an exploded view of the Ultrafiltration pump. When working on the pump, be especially careful to do the following:

- Do not lose the wear button or the shim washers inside the pump solenoid.
- Count the shim washers when you disassemble the pump. The number of washers varies as needed to mate the solenoid to the pump properly.

CAUTION

Replace exactly the same number of shims in the ultrafiltration pump as were removed. The pump will not operate correctly if the same number of shims are not replaced.

Examine all components for signs of corrosion. Replace any components that show signs of excessive rust.

NOTE

The solenoid is a sealed unit. No lubrication is necessary.

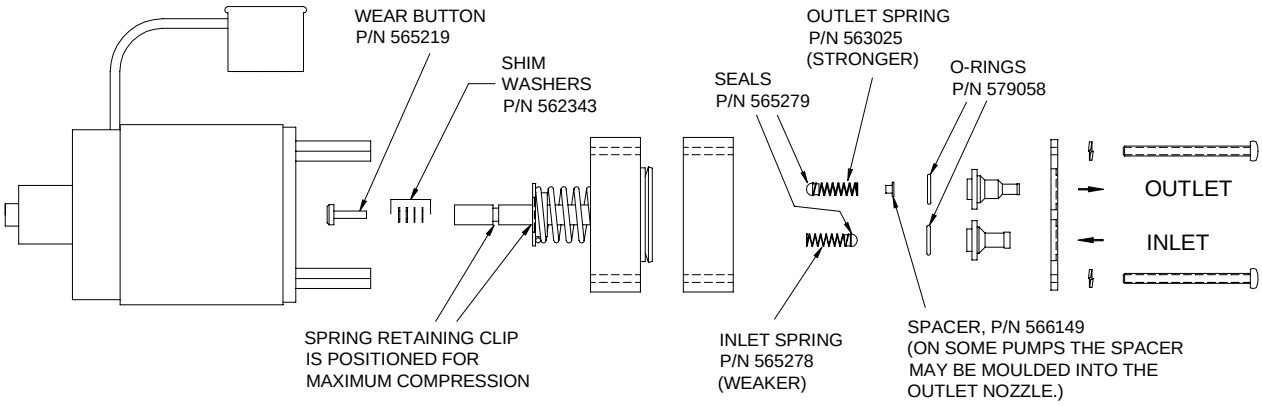


Figure 10. Ultrafiltration Pump Exploded View.

Rebuild the ultrafiltration pump as follows:

1. Remove the UF pump from the machine (Fig. 2). Make a note of which line goes to which port on the pump. When looking at the end plate, the arrow pointing into the pump nozzle is the input side. The arrow pointing away from the pump nozzle is the output side.

2. Hold the two sections of the pump housing and end plate together with one hand and remove the four long screws from the end plate.

3. Carefully remove the end plate to reveal the input and output nozzles, springs, seals and O-rings.

4. Replace the inlet and outlet springs.

CAUTION
Be certain the correct springs are used. The weaker spring goes on the inlet side. The stronger spring goes on the outlet side.

5. Inspect the seals. Replace them if there is any sign of swelling or wear.

6. Inspect the O-rings. Replace them if there is any sign of wear.

7. Reassemble the pump as follows:

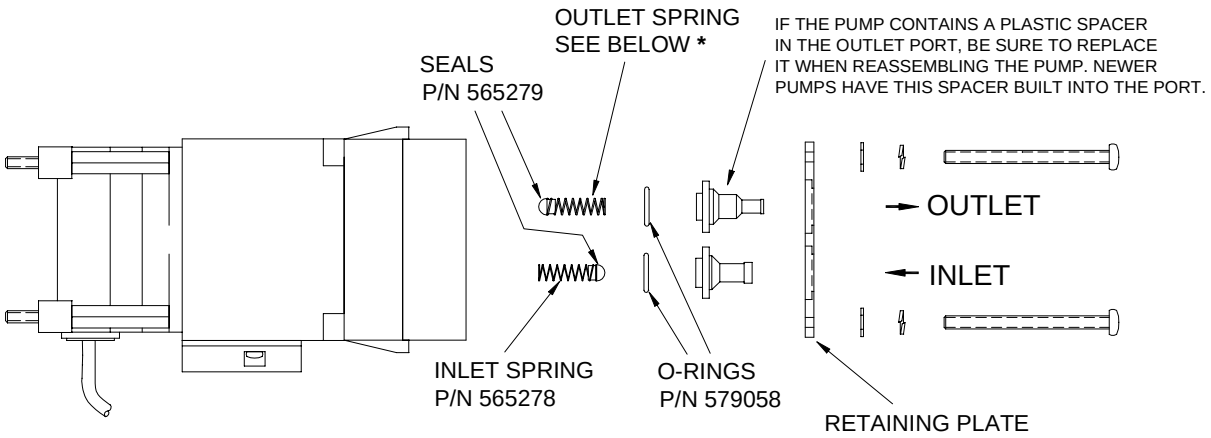
    - The outlet seal goes toward the pump membrane.
    - The inlet seal faces away from the pump membrane.
    - Reinstall the spacer in the outlet nozzle if one was removed from the pump.
    - Ensure the outlet nozzle is oriented so it will be at the top of the pump solenoid to help avoid air locks in the pump.

8. Replace the long screws into the end plate and tighten.

9. Replace the pump in the machine and reconnect the electrical and hydraulic lines. Orient the pump so the outlet nozzle is above the inlet nozzle to help avoid air locks.

4.2 REBUILDING THE CONCENTRATE AND BICARBONATE PUMPS

Figure 11 is an exploded view of the concentrate and bicarbonate pumps



***** ON CONCENTRATE (ACID) PUMPS THIS SPRING IS STRONGER THAN THE INLET SPRING. USE P/N 563025. ON BICARBONATE PUMPS USE WEAK SPRINGS FOR BOTH INLET AND OUTLET (P/N 565278).

ON MACHINES WITH ONLINE CLEARANCE (OLC), THE CONCENTRATE (ACID) PUMP USES WEAK SPRINGS FOR BOTH INLET AND OUTLET (P/N 565278).

Figure 11. Concentrate and Bicarbonate Pump Exploded View.

Rebuild the concentrate pumps as follows:

1. Remove the pump from the machine (Fig. 2). Make a note of which line goes to which port on the pump. When looking at the end plate, the arrow pointing into the pump nozzle is the input side. The arrow pointing away from the pump nozzle is the output side.

2. Hold the two sections of the pump housing and end plate together with one hand and remove the long screws that hold the end plate. On some models of the pump, all four screws hold the end plate, and on others only two screws hold the end plate.

   If you removed all four screws to free the end plate, replace one or two of them to avoid having the pump come completely apart. You only need access to the inlet seals and springs.

3. Carefully remove the end plate to reveal the input and output nozzles, springs, seals and O-rings.

4. Replace the inlet and outlet springs.

> **CAUTION**
> Be certain the correct springs are used on concentrate pumps. The weaker spring goes on the inlet side. The stronger spring goes on the outlet side.

5. Inspect the seals. Replace them if there is any sign of swelling or wear.

6. Inspect the O-rings. Replace them if there is any sign of wear.

7. Reassemble the pump as follows:

   - The outlet seal goes toward the pump membrane.
   - The inlet seal faces away from the pump membrane.
   - Reinstall the spacer in the outlet nozzle if one was removed from the pump.
   - Ensure the outlet nozzle is oriented so it will be at the top of the pump solenoid to help avoid air locks in the pump.

8. Replace the long screws into the end plate and tighten.

9. Replace the pump in the machine and reconnect the electrical and hydraulic lines. Orient the pump so the outlet nozzle is above the inlet nozzle to help avoid air locks.

4.3 TESTING CONCENTRATE AND BICARBONATE PUMPS

The concentrate (acid) and bicarbonate pumps are tested by measuring the volume of water they pump and comparing that measurement with the expected value determined by the machine. The measured pump volume must be within 2% of the expected value.

Test each pump as follows:

1. Place the machine in Dialysis mode and clear all alarms.

2. Enter Debug mode by pressing the front panel Up and Down arrow touchpads simultaneously.

3. Use the Up arrow and scroll until the following screen appears. The numbers shown here are typical values. Your machine will vary.

4. If you are using a bicarbonate pump and your display shows zero for the Bicarbonate Pump Volume (BMIN= and BMAX=), the machine is set up for a concentrate family that does not use bicarbonate. Change the concentrate selection for one requiring bicarbonate and return to this test step.

NOTE

Certain types of Bicarbonate or higher Bicarbonate levels selected will require the pump to double stroke. (Double stroke of the Bicarbonate pump can be checked by going to debug screen # 7 and look at DOUBLE. If there is a 1 the pump is double stroking.)

NOTE

The AMIN=, AMAX=, BMIN=, BMAX= are the expected limits for two hundred pulses of the acid (concentrate) pump volume and the bicarbonate pump volume, respectively. These volumes are based on the measured volume of the balancing chamber to produce the correct mixing ratio.

5. Connect a 25 ml buret filled with water to the concentrate connector for the pump to be tested. Use a short length of tubing forced over the end of the connector, and make sure there are no leaks in the fitting to the connector or to the buret.

6. With the machine in Dialysis mode, press the DIALYSATE FLOW ON/OFF touchpad to start the flow. Observe that liquid is drawn from the buret in discrete steps. Allow the machine to run and pump fluid from the buret for about 20 strokes, to prime the pump.

NOTE

Do not let the buret run dry so that air can enter the system.

7. Refill the buret exactly to the full mark. Press the DIALYSATE FLOW ON/OFF touchpad to start the flow and count exactly 20 pulses of water drawn from the buret, then stop the flow.

NOTE

Since AMIN=, AMAX=, BMIN=, BMAX= are the expected limits of two hundred pulses of the pump volume, the measured volume must be multiplied by ten before comparing it to these displayed limits. If the bicarbonate pump is double stroking (DOUBLE=1 on debug screen # 7) then multiply the measured bicarbonate volume by 20.

8. Measure the amount of water drawn from the buret carefully to within 0.05 ml (within 1/2 division on a buret calibrated in 0.1 ml increments). Multiply this amount by 10 or 20 (see previous note) and verify that this value is between the displayed limits of AMIN= and AMAX= for the acid pump volume and BMIN= and BMAX= for the bicarbonate pump volume.

NOTE

If the pump volume falls outside of the permitted error, repeat the above procedure to ensure that you are getting consistent results before re-calibrating the machine.

NOTES:

NOTES:

PREVENTIVE MAINTENANCE CHECKLIST
QUARTERLY/1000 HOUR

SERIAL NO. _____ **DATE** _____

MACHINE I.D. NO. _____ **MACHINE HOURS**_____

TECHNICIAN(S) _____ **LABOR HOURS** _____

See the Referenced Section of the Fresenius 2008H Preventive Maintenance Procedures (p/n 500558 Rev F or later) for detailed instructions to perform the following:

Ref. Section	Procedure	Completed By:
2.1	**Clean Filters (replace if necessary) and replace O-Rings:**	
	Water Inlet	_____
	Acid and Bicarbonate Connectors	_____
	Dialysate Inline Filter	_____
	Dialysate Line Connectors	_____
	Pre-UF Pump	_____
2.1A	**Replace DIASAFE® filter (If Applicable)**	_____
2.2	**Inspect Check Valves (replace if necessary)**	_____
	UF Pump Output (2 valves)	_____
	Concentrate and Bicarbonate Pump Output (if central feed)	_____
2.3	**Check UF Pump**	_____
2.4	**Check Temperature with External Meter**	_____
2.5	**Check Conductivity with External Meter**	_____
3.18	**Calibrate Level Detector**	_____
2.6	**Check Alarm Operation and Pressure Holding Test**	_____
2.7	**Check Labels and Mechanical Condition**	_____

NOTES:

_____

_____

_____

NOTES:

PREVENTIVE MAINTENANCE CHECKLIST
ANNUAL/4000 HOUR

SERIAL NO. _____ **DATE** _____

MACHINE I.D. NO. _____ **MACHINE HOURS**_____

TECHNICIAN(S) _____ **LABOR HOURS** _____

See the Referenced Section of the Fresenius 2008H Preventive Maintenance Procedures (p/n 500558 Rev F or later) for detailed instructions to perform the following:

Ref. Section	Procedure	Completed By:
3.1	Clean Filters, Replace O-Rings and Check Valves	_____
2.1A	Replace DIASAFE® filter (If Applicable)	_____
3.2	Rebuild UF, Concentrate and Bicarbonate Pumps	_____
3.3	Check Heater Element	_____
3.4	Check AC Connectors	_____
3.5	Replace Deaeration Motor Brushes (every 8000hrs)	_____
3.6	Check Inlet Water Pressure Regulator	_____
3.7	Conduct Online Clearance Test (If Applicable)	_____
3.8	Check Deaeration and Loading Pressure	_____
3.9	Check Flow Relief Pressure	_____
4.3	Test Concentrate and Bicarbonate Pumps	_____
2.3	Test UF Pump	_____
3.10	Check Temperature Calibration	_____
3.11	Check Conductivity Calibration	_____
3.12	Check Volt Hi Lo Detect	_____
3.13	Check Blood Leak and Dimness Calibration	_____
3.14	Check Arterial, Venous and TMP Calibration	_____
3.15	Check Dialysate Flow	_____
3.16	Check Heparin Pump (If Present)	_____
3.17	Check Blood Pump	_____
3.18	Calibrate Level Detector	_____
3.19	Check Alarm and Pressure Holding Tests	_____
3.20	Rinse Checks	_____
3.21	Check Battery and Power Failure Alarm	_____
3.22	Check Internal Blood Pressure Module (If Present)	_____
3.23	Final Checks	_____

NOTES:

NOTES:

NOTES:

COMMON CONVERSIONS

PRESSURE

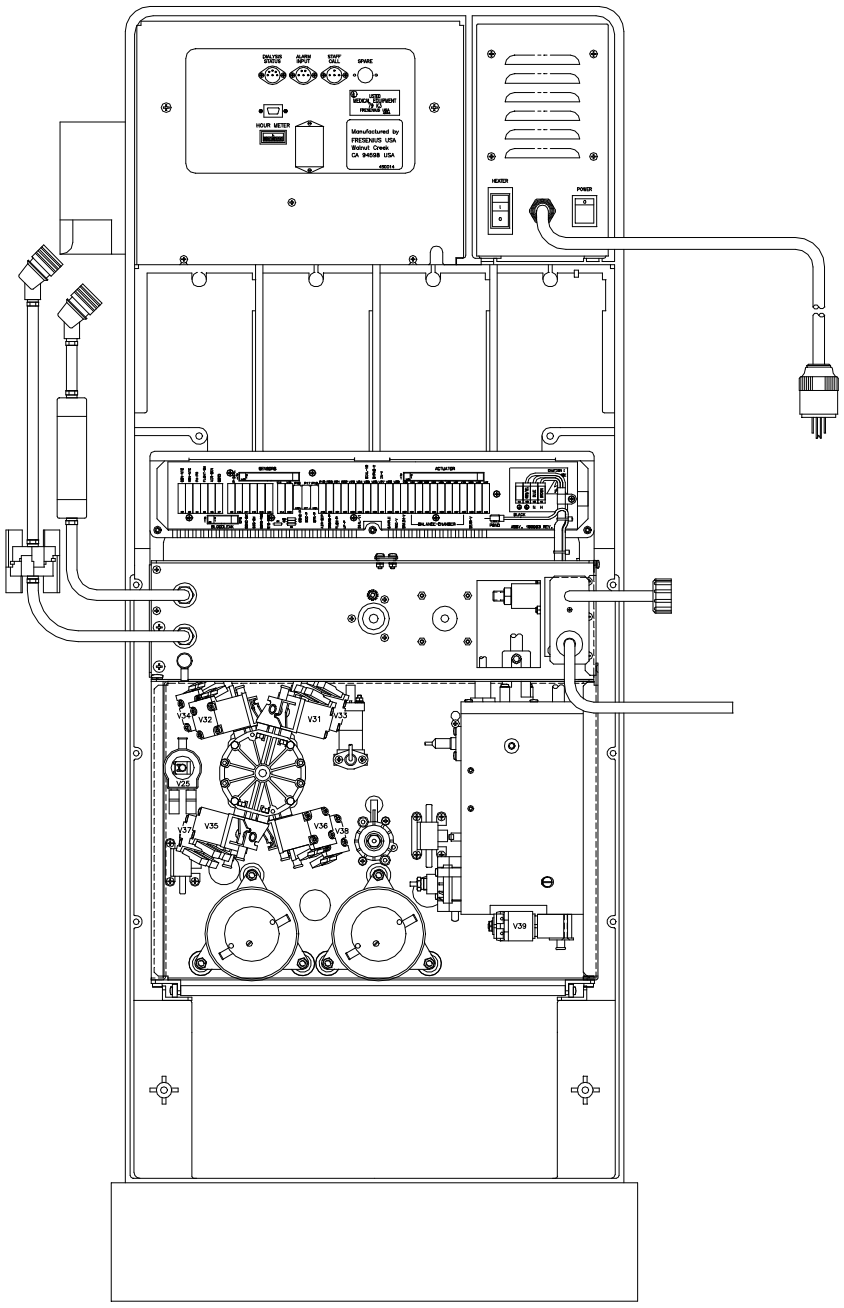
1 Bar	29.53 inHg
1 inHg	25.4 mmHg
1 Psi	51.72 mmHg

VOLUME

1 FLUID OUNCE	26.6 MILLILITERS
1 U.S QUART	0.946 LITERS
1 U.S. GALLON	3.8 LITERS
0.034 FLUID OUNCES	1 MILLILITER
1.057 QUARTS	1 LITER
0.26 U.S. GALLON	1 LITER

MASS

1 OUNCE (avdp.)	28.35 GRAMS
1 POUND (avdp.)	0.45 KILOGRAM
0.035 OUNCE (avdp.)	1 GRAM



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